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SCIENCE VISION

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Tables and Illustrations: (i) should be separate from the text; (ii) should be numbered according to the order in which they are mentioned in the text; (iii) facts and figures should be carefully revised and any discrepancies removed; (iv) each table should have a short explanatory caption.

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SCIENCE VISION

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COMSATS FOUNDATION-STONE LAYING AND UNIVERSITY STATUS FOR CIIT

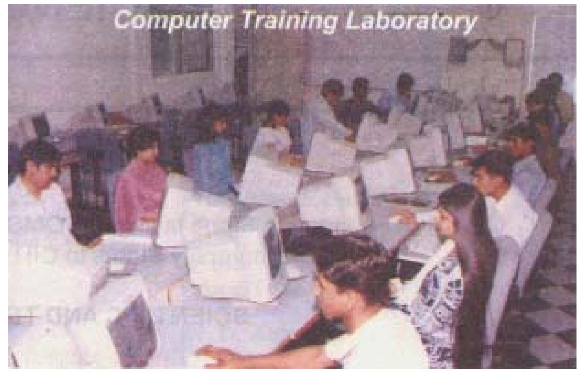
PRESIDENT LAYS FOUNDATION-STONE OF COMSATS HEADQUARTERS BUILDING

H.E. Mr.Muhammad Rafiq Tarar, President of Islamic Republic of Pakistan laid the foundation stone of COMSATS Headquarers Building in Islamabad, on Tuesday April 18, 2000. Prof. Dr. Atta-ur-Rehman, Federal Minister of Science and Technology, was also present on the occasion. Dr. Hameed Ahmed Khan, Execuitve Director COMSATS, alongwith other officials, welcomed the distinguished guests on their arrival at the builidng site in Sector G-5/2, opposite Radio Pakistan. H.E. The President unveiled the Foundation Plaque of COMSATS Headquarters, in the presence of dignitaries and diplomats of the Foreign missions residing in Islamabad. All those present prayed for the success of the project. The chief guest was then given a brief presentation by NESPAK, consultatns of COMSATS, on the structure and design of the construction project.

After the ceremony at the site, the guests were escorted to the Auditorium of Pakistan Academy of Sciences on Constitution Avenue, for the proceedings. Dr. Hameed Ahmed Khan, Executive Director of COMSATS, in his welcome address, gave a brief review of COMSATS' activities. He thanked the President and Federal Minister for gracing the occasion.

The Federal Minister for Science and Technology, delivered the keynote address, highlighting the importance of south-south cooperation, and stressed that the developing countries need to develop their own resources in the field of science and technology.

H.E. President of Pakistan in his speech commended the efforts put in by the Commission to establish itself firmly duirng the short period of five years. He said that it was essential to house the orgnaization in its own premises, so that it can operate from a firm base and play its part effectively, to carry out the mission of highlighting the centrality of science and technology in the process of development, and to ensure proper liaison among the scientific and technological establishments of its 21 member states.



DEGREE-AWARDING STATUS FOR COMSATS INSTITUTE OF INFORMATION TECHNOLOGY

The Federal Cabinet of Government of Pakistan has approved the charter of COMSATS Institute of Information Technology (CIIT), a project of Commission on Science and Technology for Sustainable Development in the South (COMSATS). The approval of the charter of CIIT is a step forward, by the governemnt, in fulfilling the commitment of granting univesity-status to maximum IT institutes in Pakistan and also in appreciation of the role of COMSATS and CIIT in the promotion of IT education in Pakistan.

Dr. Hameed Ahmed Khan, Executive Director of COMSATS, congratulted the members and students of CIIT on this occasion. He, in his message, observed that it was all by the grace of Allah, Almighty, that the cabinet has found this institute of the level that it can be entrusted with such a big responsibility. This has now increased the responsibility of the staff members and students to make this institute a success.

Dr. S.M. Junaid Zaidi, Director of the Institute, also congratulated the CIIT family. CIIT, which was established just a couple of years ago with introduction of professional courses, has now been accepted as a leading institute in Information-Technology in Pakistan. It is all becasue of the blessings of Allah and efforts of the employees, which have contributed in bringing this institute this far. He reaffirmed the resolve to make this institute not only a leading education institute in this area, but showed confidence that this institute will soon emerge as one of the leading software-development institutes in the country.

SCIENTIFIC AND TECHNOLOGICAL PAPERS

PHYSICAL SCIENCES AND TECHNOLOGY

ADVANCED CONTROL-TECHNOLOGIES FOR SUPPRESSING HARMFUL EMISSIONS IN LIGNITIC COAL-FIRED POWER GENERATION

Surriaya Mir and
*S.M. Abdul Hai**

(Received on 25-10-1999 and, in *revised form,* 15-11-1999)

ABSTRACT

The production of sufficient amount of indigenous energy is a prerequisite for the prosperity of a nation. Pakistan's energy demand far exceeds its indigenous supplies. A cursory look at the energy situation in Pakistan reveals that there is an urgent need for the development of its energy-resources.

In this regard, coal can play a key role if its problems of high sulphur and high ash can be rectified through the adoption/adaptation of advanced technologies, like (i) clean coal technologies, and (ii) control technologies. A review on clean coal technologies for utilization of lignitic coals has already been published[1] and the present article describes the effect of harmful emissions from the combustion of high-sulphur coals, like the ones found in Pakistan, and their control through advanced control-technologies, to make a significant contribution in the total energy economics of Pakistan.

INTRODUCTION

As the world has progressed through the industrial age, energy in the forms of electricity and diesel & petrol has replaced people and animals in performing work in manufacturing, agriculture and transportation. In fact, energy has become an essential component of our daily life, as food is, and those societies with abudance of energy are at the pinnacle of the present civilization.

About 40 percent of the energy produced in Pakistan is consumed by industry, while the rest is being consumed by agriculture and for other purposes. As against a total estimated existing energy demand of 9.5 GWe, just 7.5 GWe is produced in the country (Giga watt is equal to one million Kilowatts), causing a shortfall of about 2 GWe (or about 20%). To reduce the gap between energy production and demand, as also the import bill of oil, the oil and gas reserves should be preserved for superor fuel use and indigenous coal-reserves should be developed/utilized to supplement the energy needs. An estimate of energy-resource potential of oil, gas, coal and hydel is given in Table-I[1].

In Pakistan, the environmental pollution caused by combustion of coal has been a major impediment in its utilization. A substantial reduction in coal-combustion emissions is achieved through the development of suitable control-technologies. With the use of these technologies, even low-grade lignitic coals are utilized, all over the world, for energy production. Today, various countries like USA, Germany, China, Greece, Turkey, etc., use low-quality coals for production of energy. Following the example of other countries, concerted efforts have to be made in Pakistan to utilize these technologies for power-production from coal found in the country.

The energy-defficiency in Pakistan is not so much due to poor resource-endowment, as the inability to exploit the available resources. The per-capita availability of energy in Pakistan is very low, even when compared to the developing countries, see Table-II[2]. To achieve self reliance and to reduce the bills of imported energy, Pakistan too needs to produce additional energy from indigenous sources of coal. Coal can make a significant contribution in Pakistan, as we have extensive resources of lignitic and sub-bituminous coals, which are estimated at billions of tons. At present coal, in Pakistan, has a small share in the total energy-supply position, on account of its high sulphur and mineral contents.

THE COAL RESOURCES OF PAKISTAN

An account of the coal resources of Pakistan and their characteristics is given elsewhere; these reserves have been estimated at over 183 billion tonnes. The

* Pakistan Council of Scientific and Industrial Research, Fuel Research Centre, Karachi.

Table - I
Energy Resources Potential of Pakistan

	Probable	Possible
Oil (Billion Barrels)	13.2	97-404
Gas (TCF)	40	1443
Coal (Billion Tons)	2.94	22.13
Hydel (MW)	28,345	40,000

Source:

Oil	ECL Study, World Bank
Gas	ECL Study, World Bank
Coal	GSP (Geological Survey of Pakistan
Hydel	WAPDA and Working Group

Table - II
Energy Supplies and Per-Capita Availability

	Energy Supplies (mln TOE)	Per Capital Availability (TOE)
1991-92	30.793	0.262
1992-93	32.981	0.273
1993-94	34.784	0.279
1994-95	36.115	0.282
1995-96	38.750	0.292

Source: Hydrocarbon Development Institute of Pakistan

largest coal field discovered by Geological survey of Pakistan in 1992, is located in Thar Desert. During July 1996-March 1997, 2,366 thousand tonnes of coal was produced and consumed in the country. Major share of the production was consumed by brick-making sector (88.25%), followed by power sector (11.36%) and households (0.39%).

Pakistan's coal reserves, which are distributed in the major coal fields of various provinces are briefly described below:

Baluchistan: The known coal-producing fields include Duki, Khost-Sharig, Harnai, Pir Ismail Ziarat, Mach-Abe-Gum, Sor-Range-Deghari and Ghamalong-Bahlol; the overall resource-potential is over 194 million tonnes, with measured reserves of 52.5 million tones. Average annual prodcution is about one million tonnes.

N.W.F.P: Hangu is the only coal-producing field in NWFP. Some sporadic mining is reported from Cherat. The resource-potential is over 44 million tonnes, with measured reserves of 0.5 million tonnes. The production is insignificant.

Punjab: Substantial resources of coal have been outlined in the Eastern and Central Salt Range and in Makerwal area of the Surghar Range. A coal resource potential of 234 million tonnes has been projected, with drill-proved reserves of 43 million tonnes. Although several coal-seams are developed, only one is being mined throughout the province. The average annual production is 450,000 tonnes.

Sindh: A very large coal-resource exists in the Sindh province. Coal-resource potential in excess of 183 billion tonnes has been outlined in Lakhra Sonda-Jherruck, Indus East, Thar and Badin coal fields. Measured reserves are over 73.4 million tonnes. The coal being produced is high in sulphur. The known coal-fields, from where mining is reported, include Lakhra and Meting-Jhimpir. Average annual production is about one million tones[2].

ADVANCED-TECHNOLOGIES FOR CONTROL OF EMISSIONS FROM COAL-COMBUSTION

The research and development efforts addressed to the environmental control of coal-combustion emissions are classified as under :

i) The advanced clean-coal technologies are the recently developed technologies that utilize low-grade lignitic coal, controlling environmental discharge during combustion without the use of outside scrubbers. Detailed perspective applications of these technologies in indigenous coal-fired power-production have already been discussed in an earlier paper[1].

ii) The advanced control-technologies are in practice for quite some time and are widely used in large pulverized-coal-fired power plants, the world over. These technologies use the techniques for NO_x removal and collect ash and sulphur oxides emissions through sophisticated techniques, converting them into useful products. The possible application of advanced control technologies in lignitic coal-fired power generation is being addressed in this paper.

Some of the hazardous pollutants produced by coal combustion and their effects on health/environment are first summarized, as under:-

1. The Hazardous Emissions Produced by Combusion of Coal

To achieve environmental safety, for using coal as a fuel, the emissions of three recognized atmospheric pollutants need to be suppressed:

(1) the oxides of sulphur,
(2) the oxides of nitrogen, and
(3) extremely fine particulate matter.

Each of these pollutants poses unique threats to ecological conditions and human health. Sulphur oxides, predominantly sulphur dioxide (SO_2), are formed from the combustion of the sulphur contained in the coal, whether in the form of iron pyrites (FeS_2) or as elemental sulphur. The emissions may travel in the upper atmosphere over long distances, depending on climatic conditions, and get oxidized to sulphur trioxide ($S0_3$), dissolve in atmospheric moisture and fall as acid rain, which adversely affect human health and cause fish in lakes to die and deteriorate forest vegetation.

Nitrogen oxides are formed in the combustion of all fossil fuels, the amount depending on the conditions of the combustion, particularly the temperature of the combustion. High-temperature combustion leads to the chemical combination of the nitrogen and oxygen in the air. Nitrogen-containing compounds are found along with the coal; this nitrogen upon liberation is chemically active and combines readily with available oxygen. Nitrogen oxides; or NO_x, are a mixture of several discrete nitrogen/oxygen compounds. In the upper atmosphere, they readily enter into complex chemical reactions with the ozone, catalyzed by ultraviolet radiation, to form a series of acrid compounds that make themselves felt as “smog” and atmospheric haze.

The third pollutant i.e. the particulate matter is especially specific to coal. It is composed of mineral and some unburnt combustible matter and trace elements. In addition to the obnoxious effect of the smoke formed by the combustion of aromatic hydrocarbons, the trace elements in particulate may be fine enough to be breathable. Some gaseous and particulate substances from coal combustion and their toxicity and environmental standards are shown in Table-III[4].

We may define the environmentally safe, the clean use of coal, as the use of coal under such combustion conditions that the excessive emissions of sulphur oxides, nitrogen oxides, and particulate matter are avoided. In many countries, the term “excessive” is defined legally by regulatory agencies, and compliance by coal consumers with these definitions has the force of law. The developmental lending agencies, such as the World Bank, have adopted conditions for their lending that ensure compliance with their own regulations for permitted emissions. The solution of the problems that arise in connection with the “Clean” use of coal are thus not simple. The combustion-equipment must be capable of suppression of sulphur oxides and nitrogen oxides emissions, and the particulates must be captured to the extent that law or good environmental practice requires[5]. In Pakistan, the problems are intensified because the sulphur-content of almost all the coal deposits is unusually high and the same is true for their mineral content.

USE OF TECHNOLOGIES IN COAL-COMBUSTION EMISSION

The control-technologies utilized in power generation by pulverized coal-firing involve (a) the collection/utilization of the particulate matter i.e. ash, and (b) the capture of gaseous emissions, mainly sulphur dioxide, and the proper utilization of the products without polluting the environment and the removal of NO_x produced by coal-combustion. These are described below in some detail.

(a) Ash Collection/Utilization Through Control Technologies

(i) Ash Collection Technologies: Large coal-burning boilers usually fire pulverized coal. The components of the fuel that cannot be burned or gasified are obtained as ash. The bottom-ash collected in the furnace has found little use and is generally put in the landfill. The ash that is present in the dust form and carried out with the gas is called "fly ash". The composition of fly ash is essentially the same as the bulk composition of the ash in the coal from which it comes. The principal difference is that the fly ash consists of particles that have been heated to temperatures ranging from about 1400 to 1700°C. This "fly ash" pollutes the atmosphere when released with the combustion-gas and the ground-water if removed from the gas and discarded in land disposal area. Many advances in the understanding of the behaviour of ash in coal have been made and effective techniques for ash collection/utilization have been developed. Finely divided "fly ash" is usually removed by cyclonic separation, electrostatic precipitation, filtration and wet scrubbing techniques.

Electrostatic precipitation is, by far, the most widely used ash-collection method[6]. Low pressure drop, high collection efficiency and dependable operation make it the standard choice for large boilers and, quite often, for small ones. Electrostatic precipitation is a very complicated phenomenon. The basic principle is of suspending electrodes in the gas-stream and imposing a potential difference between the electrodes and a ground collection surface. Ionization of the gas by the high potential causes the particles to pick up a charge They are thus attracted to the collection area; the collector plates are vibrated to shake off the collected particulates into a hopper.

ii) Utilization of Fly Ash: The major market for "fly ash" has been in concrete. Addition of Ash to concrete reuslts in lower water-requirement, higher ultimate strength, improved workability, lower permeability and less heat-generation during curing. In cement-manufacture, "fly ash", added to the raw batch before burning, can provide an inexpensive source of silica and alumina[7].

Soil stabilization with "fly ash" for road areas, airport runways, parking areas and foundations has been practised fairly extensively and, in many cases, lime is also added[8].

Table - III: Toxicity of Some Gaseous and Particulate Substances from Coal-Combustion

Substance	Toxicity	
	Acute	Chronic
Particulates: total suspended particulates	With SO_2 in episode conditions, contributes to mortality and morbidity.	Pulmonary irritation, chronic obstructive & restrictive lung disease
Sulphur Oxide	Increased respiratory disease; breathing difficulty in asthmatics	Respiratory disease and increased mortality suspected.
Nitrogen oxide	Increases infant susceptibility to lower respiratory infection due to conversion of nitrates into nitrites	May combine with amines to form carcinogenic nitrosamines; also mutagenic & teratogenic Nitrites constitute a direct animal carcinogen

Table - IV: Products of Flue-Gas Sulphur removal, in a 600 MW Power-Plant, Opeating 4000 hr/year and using 2% Sulphur Bituminous Coal; heating value 29.3 x 10^3 KJ/Kg and 80% Removal Efficiency; Yields Depend on Process Used

Product	Amounts (10^3 kg/year)	Process
Sulphur	128,000	Bergbau-Forschung, IFP, Wellmand-Lord SFGD
Sulphuric acid (100%)	390,000	Wellman-Lord, Sumitomo, Monsanto, Lurgi-Sulphacid, Bergbau-Forschung
Sulphur dioxide	256,000	Wellman-Lord, Chemico, Sumitomo, Bergbau-Forschung
Gypsum ($CaSO_4 \cdot 2H_2O$)	692,000	Chiyoda-Holter, Mitsubishi-Jecco, Chemico
Sludge (e.g. 70% $CaSO_3$ 1/2 H_2O) 15% $CaSO_4 \cdot 2H_2O$ 15% $CaCO_3$		Bischoff, Bahco, Combustion Engineering, Chemico

iii) Removal of the Fine Particulate from Fly Ash: The fine particulates escaping from "fly ash", although in minor concentration, cause pollution from contained trace-elements. They are collected through many collection equipments, like electrified filters, sonic agglomeration, charged droplet scrubbers, wetted mesh filter and high-pressure nozzle.

(b) Control of Gaseous Emissions from Coal Combustion

(i) Control of Sulphur Oxide: Most of the processes for removing sulphur oxides from the gases involve contacting the gas with a material that combines with the sulphur oxides, thus converting them to a liquid or solid that can be removed and utilized. Most of the processes for removal of sulphur dioxide use limestone or lime, through wet-scrubbing or dry-scrubbing processes.

Use of the wet-scrubbing operation, with lime or limestone as the absorbent, is by far the most popular method for removing SO_2 from waste gases[4]. A high degree of removal can be attained, with good utilization of the absorbent. Despite several unresolved design and operating problems, the advantages are such that companies operating large boilers seldom give much attention (in planning) to any process other than lime or limestone scrubbing.

Many other processes, like sodium, ammonia and magnesia-based scrubbing and metal-oxides absorption, are now developed and success is being achieved.

(ii) The Useful By-Products of Flue Gas Desulphurization: Depending on the process, the sulphur dioxide removed from flue gas can be obtained in the form of a variety of chemical compounds. These can be converted into final saleable products, like gypsum, sulphuric acid, liquid SO_2 and elemental sulphur. Such compounds may be a sludge that contains $CaSO_3$ in addition to gypsum. Table-IV shows the annual quantities of these different products obtained in a 600 MW power-plant fired with bituminous coal containing 2% sulphur. The plant removes 8% of the sulphur and operates 4,000 hours/year. The table also shows the most important flue-gas sulphur removal processes that yield these products. In various countries of the world, different interests exist for the manufacture and use of individual products[4]. In the United States, lime and limestone-scrubbing processes contribute 80% to all flue-gas desulphurization (FGD) and produce gypsum of gas sludge as a final product[4]. It has become possible to convert sludge into material strong enough to be used in the building sector and in highway building.

A major adantage of the FGD system is that the reagent (limestone) is inexpensive and generally available. There are about 120 GGD systems in USA, 100 in West Germany and 56 in Japan and a few dozens in Europe, in operation based on lime or limestone. FGD systems for SO_2 removal may be sucessfully employed for Pakistan coals for future power plants.

(iii) Control of Nitrogen Oxides: There are several differences between controlling nitrogen oxides emissions from coal-combustion and controlling emission of particulates of sulphur oxides. The first difference is that a smaller amount of NO_x is emitted compared to other emissions. In addition, there is not much that can be done about the amount of ash and sulphur involved, both are present in the coal and must come out as the waste product, whereas much of the NO_x comes from the air and is produced by the reaction of nitrogen and oxygen at elevated temepratures. Thus, the amounts of NO_x vary with the boiler conditions and the emission is generally a direct function of flame temperature, excess air, nitrogen content in coal, percentage of boiler-load and rate of gas cooling.

The general approach in reducing NO_x emission is to alter the combustion conditions. The control of combustion to reduce formation of NO_x is more economical than the removal methods. The combustion-control either utilizes the modifiction in boiler or burner-design, staged combustion and re-circulation of the combustion gas to avoid the formation of NO_x, or uses the treatment of NO_x with ammonia or a catalyst to convert it into nitrogen and carbon dioxide[4].

NATIONAL SCENARIO

The development of the coal-sector, particularly of Lakhra and Thar, needs to be stepped up in order to provide fuel for WAPDA power projects. For utilizing Lakhra coal in power-generation, various feasibility studies were made for installing Lakhra coal fired power-plants, using control technologies by GSP, USGS, JICA. Detailed feasibility study was performed by John T. Boyed and Co. (USA), on behalf of USAID/WAPDA, for utilizing Lakhra coal for power-generation. Capital cost of mining and installation of power-plant was determined. Lakhra coal was tested for boiler design and assessment of environmental-impact was made by US consultants. Following the World Bank Guidelines, proper studies were made to establish that Lakhra power-plant was a component of the least-cost power-generation programme of WAPDA and the cost of coal from Lakhra mine was able to produce electricity that was more economical than any other available source of fuel, like imported coal or imported oil. Under the Energy Planning and Development Programme, with the assistance of the World Bank, Asian Development Bank and USAID, these investigations were completed. It was concluded that the Lakhra coal mine power-generation project, using Lakhra coal would be technically, financially and economically feasible and will be socially and environmentally sound, using flue-gas desulphurization technique[9-10].

Environmental-impact assessment by US experts has suggestd that 3x50 M.W. plants should be preferred at Lakhra, and that would not exceed the maximum limit of SO_2 impact in the environment, as set by World Bank standards. Inthis regard, Lakhra coal-development Co, which is a joint-venture company, having equity share of PMDC (30%), WAPDA (20%), Government of Sindh (20%), while the remaining 30 percent is reserved for the private sector participation, has pledged to supply 750,000 tonnes of coal per annum to WAPDA for its 3x50 MW coal-fired plant at Khanote (Sindh). LCDC produced 258,055 tonnes of coal from its small coal-mines during July-March 1996-97[2].

Beside the production of indigenous energy from the power plant, other factors like domestic, economic and industrial development in an undeveloped area of the province of Sind, providing jobs for workers, increasing energy, self-sufficiency and reducing foreign-exchange expneses are some of the advantages that favour the developemnt of a coal-based technology at Lakhra. It may be envisaged that, with the use of control-technologies, the generation cost with indigenous coal, even after providing for environmental-control cost due to its high sulphur and ash content, may still be considerably less than the oil-based generation plant.

Concerted efforts are being made for the prospective utilization of Thar coal for power generation. USGS have performed studies on the characterization of the coal and progress is being made for its evaluation as a source of power generation.

CONCLUSION

For a nation to prosper, it is imperative that the nation should be able to effectually exploit its natural resources. Pakistan is endowed with huge reserves of low-rank coal, which, due to their high sulphur and ash content, so far have a meagre share in the total overall energy-supply of the country. These resources, if exploited properly, can make a significant contribution in narrowing down the gap between the supply and demand of energy. The control technologies, as are being utilized in the world in a manner that protect the environment to generally accepted world-wide standards, can be adopted in Pakistan. Thus, Pakistan coals may be utilzied in power-generation, resulting in the partial substitution of natural gas and oil, and making a visible impact on the future energy-economy of Pakistan.

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FLOTATION OF COPPER MINERALS FROM NORTH WAZIRISTAN COPPER ORE, ON PILOT-SCALE

*M. Mansoor Khan, Mazhar Rafiq and Ehteshamullah Khan**

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ABSTRACT

Flotation process parameters were studied to concentrate the copper content i.e. Chalcopyrite of North Waziristan copper-ore on Pilot-scale to obtain a copper concentrate suitable for further metallurgical treatment. The important flotation parameters, e.g. type and dosage of collector, dosage of depressent, dispersent and frother and conditioning time for collector were examined. During stepwise optimization of flotation parameters, the copper content was upgraded from 0.9% to 20% in roughing stage, and to as high as 22% in a single-stage cleaning, with recoveries of over 83%. A flowsheet depicting different products of flotation, for an industrial concentrator, has also been suggested.

INTRODUCTION

In North-Waziristan, at places like Shinkai and Degan, huge deposits of copper are available. The inferred ore-reservers are 122.71 million tons,having a copper content varying from 0.3865% to as high as 2% (FATA DC, 1985); (Wang Zhitian, 1996). The purpose of this paper is to study concentrateion of the North Waziristan copper ore (Shinkai area), having copper content 0.9% to a level suitable for metallurgical treatment. The western part of Waziristan constitutes a complex igneous belt. The belt extends Northeast-Southwest and consist of ultramafic masses, consisting of harzburgite, pyroxenites, periododites and dunites, generally serpentinized. The intrusives comprise diorites, quartz-diorites, micro-quartz diorites, granodiorites, dolerites and gabbros.

Volcanics include fine-grained porphyritic pillow basalts and andesites, with subordinate breccias and minor dacite, rhyodacites, tuffs and agglomerates (Badshah 1983).

To reconfirm the previously carried out studies (Khan, 1994), laboratory-scale petrographic studies of the ore showed that the sulphide mineralization is present in the form of the stock work-internally brecciated. The suphide minerals are disseminated and are in skeletal form. The pillow breccia is chloritized and contains minerals like hornblende and pyroxene. The ore-minerals are mostly cube-shaped, sporadically distributed throughout the rock but also found in the form of veinlets. Chalcopyrite exists as a major mineral, with malachite, azurite, tennantite as minor valuable minerals. Pyrite, pitchlimonite, bronchantite, graphite, chamosite, nimite and quartz exist as gangue minerals (Rafiq Mazhar, 1999).

PILOT-PLANT FLOTATION STUDIES

The aim of the present research is to develop an economically viable commerical process to utilize the 122 million tons of copper ore of the North Waziristan area.Pilot-scale flotation studies were carried out to upgrade its copper-content by physical concentration method to a level which is suitable for metallurgical treatment to produce blister copper. Flotation-process parameters, such as collector type and dosage, dispersent, pulp density, etc, were investigated.

FLOTATION TEST-PROCEDURE AT PILOT SCALE

Minerals

The copper ore was from the Shinkai area (North Waziristan) and assayed at 0.9% Cu, 0.0134% Zn, 0.0126% Pb, 0.0110% Co, 0.0067% Ni, 1.740 ppm Ag, and 0.22 ppm Au. Quartz was the main gangue mineral.

Communition

For each test-run of the flotation-process, approximately 100 kgs of copper ore was reduced in size to 80% passing 4mm. The crushed material was wet-ground for 20 min in a closed-circuit ballmill classifier, at a solid-liquid ratio of 1:2.3 (i.e. 30% solids by weight), to 80% passing 75mm. The coarse particles were difficult to float, so the grind was chosen to be fine i.e. 75mm (Rafiq Mazhar, 1999). The fine-

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Table 1. Pilot-Scale Flotation Process Parameters

Test	Pulp Density Weight/Volume gms/ton	Collector Dosage gms/ton	Frother Dosage	Pulp pH	Depressant Dosage gms/ton	Sulphidizer Dosage gms/ton	Dispersent Dosage gms/ton	Reagent Conditioning Time (Min)	
1-5	30	50~250	75	11	0	0	0	10	Bulk Roughing - I
6-10	30	50-250	75	11	0	0	0	10	
11-15	30	50-250	75	11	0	0	0	10	
16-20	30	200	75	10~12	0	0	0	10	
21-25	30	200	75	11.5	10~30	0	0	10	
26-30	30	200	75	11.5	25	10~60	0	10	
31-33	30	200	25~70	11.5	25	50	0	10	
34-37	15~35	200	46	11.5	25	50	0	10	
38-41	30	200	46	11.5	25	50	0	10~18	
42-46	15	40	40	8~12	0	0	0	10	Bulk Roughing - II
47-50	15~30	40	40	10	0	0	0	10	
51-55	25	0~90	40	10	0	0	0	10	
56-59	25	10~90	40	10	0	0	0	10	
60-63	25	60	0~60	10	0	0	0	10	
64-67	25	60	100	10	0	0	0	7~16	
68-71	20	40	35	10~11.67	0	0	0	8	Cleaning - I
72-76	20	40	35	10	0	0	0~180	8	
77-80	20	10~40	35	9.5	0	0	150	8	
81-83	20	10~30	35	9.5	0	0	150	8	
84-87	10~19	20	35	9.5	0	0	150	8	
88-91	15	20	35	9.5	0	0	150	5~14	

size grinding also promotes the self-induced flotability of the particles (Senior G.D. and Trahar W.J., 1976).

Flotation Testing

The product of the ball-mill was conditioned and subjected to flotation in a bank of 25 and 28 litres flotation-cells. All the reagents were added in the conditioning stage, except caustic soda (NaOH) which was added during the grinding stage as pH regulator. The conditioned pulp was subject to two roughing-stage flotations and one cleaning-stage flotation. The concentrates from the Bulk Roughing-I and Bulk Roughing-II were combined and cleaned, to obtain the final concentrate. For Bulk Roughing-I, the parameters investigated were type and dosage of collector, depressant dosage, sulphidizer dosage, pine-oil dosage, dispersent dosage and conditioning time. In any stage of flotation . i.e. roughing or cleaning, while studying the effect of variation of any parameter on the grade and recovery of copper, the rest of the parameters were kept constant. (Table 1). Normal tap-water was used for conducting all the tests. All the reagents were of technical grade, except sodium cyanide (NaCN), caustic soda (NaOH) and sodium sulphide (Na_2S) which were of commercial grade. Chemical analyses were carried out with X-Ray Spectrometer System (Jeol, Model JSX-603).

FLOTATION TESTS FOR BULK ROUGHING-I

In the flotation method of concentrating minerals, fast floating minerals are recovered in bulk-roughing stages, in order to obtain maximum recovery of valuable minerals (Wills B.A, 1985). The parameters investigated during this stage were type and dosage of collector, pH value, depressant dosage, sulphidizer dosage, pulp density, and pine-oil dosage. Generally, higher dosages of reagents are used during this stage of flotation.

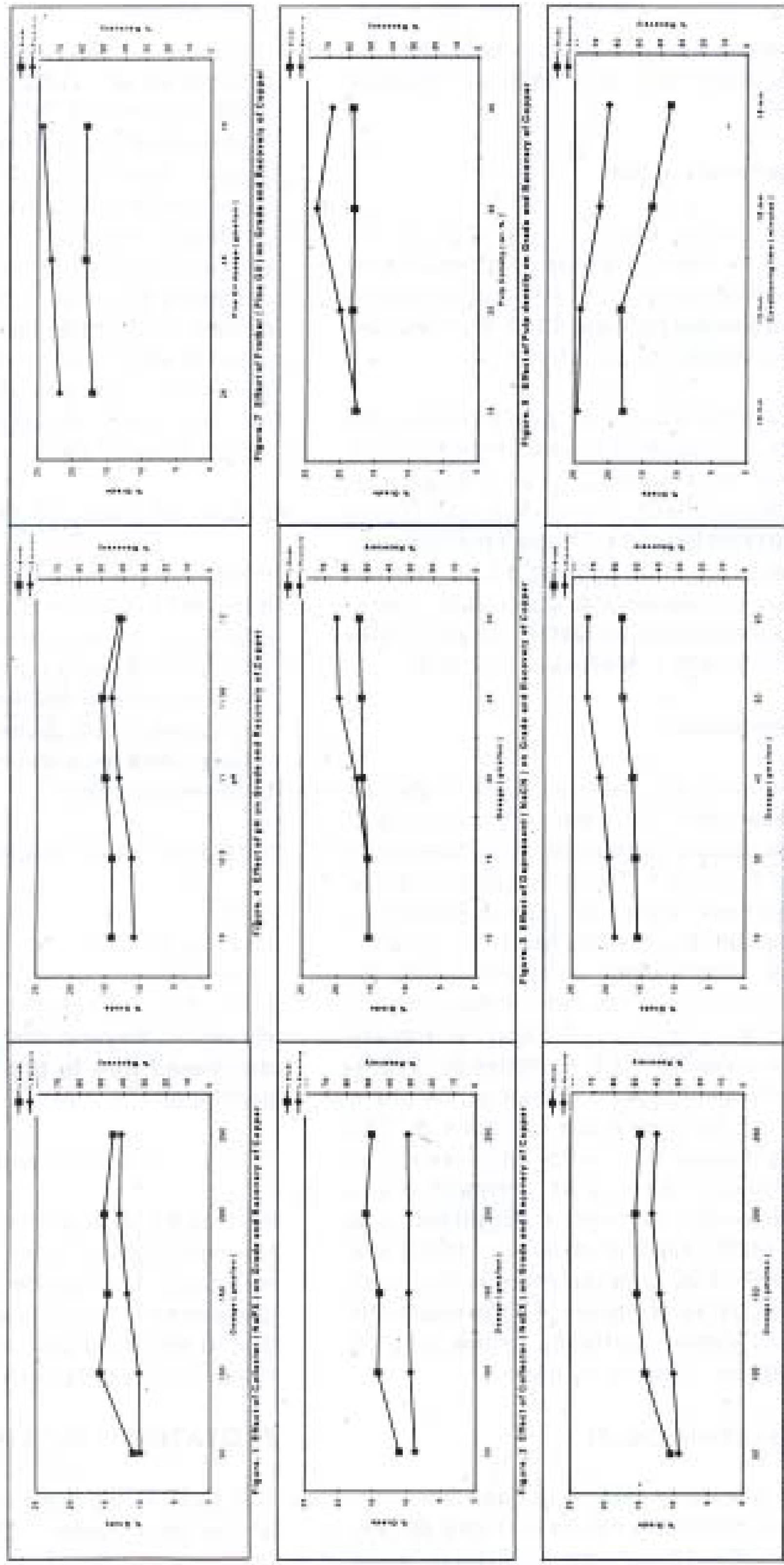
Details of Tests

Fifteen tests were carried out to evaluate the flotation- response , using different dosages and. type of collector. Five tests were conducted each to investigate the effect of varying pH and depressent dosage on the grade and recovery of copper. The effects of sulfidizer was investigated by using dosage in the range of 10- 60 gms/ton. Three tests were conducted to investigate the effect of pine oil (frother) by varying its dosage between 25 and 70 gms/ton. The effect of variation in pulp-density was investigated by varying it between 15 and 35%. Similarly, a few tests were conducted to investigate the effect of conditioning--time on the grade and recovery of copper. All the products, including tailings, recovered during. flotation test work, were dried and analyzed for copper. From the results, grade and recovery curves were drawn. The concentrate from the Bulk Roughing-I was then routed to the cleaning stage.

DISCUSSION OF RESULTS

Collector Type and Dosage

The curves in Figure 1 (Tests 1-5) show that, with an increase in NaPX (Sodium Propyl Xanthate) there is a corresponding increase in the grade/ recovery of copper (Ralston V.E., 1991, Senior, 1991, Keble 1982, Woods, 1971, Ross, 1981, Swat 1991). Beyond the dosage of 200 gms/ ton, there is a decrease in grade and a slight decrease in recovery. This may be due to the non-specific adsorption of the collector by the gangue particles (Woods, 1971; Ross,1991) and, possibly, due to the development of collector multilayers on the particles, reducing the proportion of hydrocarbon radicals oriented into the bulk solution (Smart 1991; Fuerstenau and Palmer 1976; Smith and Akhtar, 1976), thus reducing the grade of the concentrate; the critical dosage of NaPX observed at this stage was 200 gms/ton. The curves in Figure 2 (Tests 6-10) show a similar behaviour of NaEX (Sodium Ethyl Xanthate) to NaPX. By using NaEX, the grade/recovery is almost the same upto 150 gms/ton but, later, the recovery has not improved as in case of NaPX. This may be due to the fact that hydrophobic action of Xanthate collectors decreases with the, decrease in molecular weight of the alkyl group (Wills,1985); (Majima and Takeda, 1968); (Kelly and Spottiswood, 1982). The curves in Figure 3 (Tests 11-15) show the effects of KPX (Potassium Propyl Xanthate) on the grade and recovery of copper. The curves reveal a similar behaviour of KPX to that of NaPX. By using collector KPX, there is not much effect on the grade/recovery of copper



in the concentrate. Hence, Sodium or Potassium cation in collector has no effect on flotation (Crozier, 1991).

Effects of Variation in pH

In the earlier tests, the pH was kept at 11. Chalcopyrite is always flotable in oxidizing environment (alkaline medium) and non-flotable in reducing environment (Woods 1950; Buckley and Woods, 1985, Buckley et al., 1976).

Hydroxyl ions participate in the depression effect on pyrite by the formation of mixed films of Fe(OH) and FeO(OH), so reducing the adsorption of Xanthate (Kelly et al 1982). It is evident from Figure 4 (Tests 16-20) that pH of 11.58 gives the optimum grade and recovery. But beyond 11.58 pH, the grade/recovery is considerably decreased. This is due to the deactivation of NaOH on the coper minerals. (Crozier 1991; Majima et. al 1968).

Effect of Depressant

In the previous tests, that is Tests 1-20, no depressent was used. Thus the collector used in the tests also floated a considerable amount of FeS_2, and free Iron with it. This is because xanthate collectors also have higher adsorption properties for Fe-bearing sulfide minerals like FeS_2 (Pyrite). Cyanides are widely used as depressents for pyrite. Examination of cyanide-depression is indicated to be electrochemical in nature (Sutherland and Wark., 1955, Fuerstenau, 1962). The positive effects of sodium cyanide on the grade and recovery of Cu are shown in Figure 5. The figure clearly shows that, with an increase in depressent dosage, there is an increase in the grade and recovery of copper (Elgillani, and Fuerstenau, 1968, Kipie and Wells, 1982) but beyond the limit of 30 gms/ton there is decrease in grade and recovery of copper. This is due to the deactivation of copper particles in the pulp by sodium cyanide as complex cyanides.

Effect of Sulphidizer (Na_2S)

The effect of sulfidizer (Na_2S) dosage was also investigated, as shown in Figure 6 (Tests 26-30). Sulphidizers are used to activate oxidized minerals and have recently been shown to induce flotation. (Walker et al., 1983; Yoon, 1981, Walker et al. 1984; Luttrel and Yoon 1984; Heyes and Trahar., 1984). Sodium sulfide activates the oxidized copper minerals by forming a psuedo-sulphide layer on them (Franks, 1975). The curves show a gradual increase in the grade/recovery of copper with increase in Na_2S dosage. The most effective dosage is 50 gms/ton. Beyond that, there is a slight decrease in grade and recovery of copper. This may be attributed to depressing action of Na_2S, through it's ability to decrease the potential of the flotation pulp beyond critical amount (Woods, 1976); (Trahar 1983).

Effect of Pine Oil (Frother)

Frother imparts stability to the mineral froth and helps both in acheving higher-grade concentrates and recovery. As can be seen in Figure 7 (Tests 34-37) the recovery of chalcopyrite is enhanced in the presence of frother (Woods, 1950; Buckley. and Woods 1985; Buckley et. al, 1976). Pine oil is widely used as a frother; the best dosage found out is 46 gms/ton.

Effect of Pulp Density

Figure 8 (Tests 31-33) shows that, with an increase in pulp density, the recovery/grade shows an upward trend due to hindered settling conditions upto 30% optimum pulp density (Wills 1985). However, beyond that, the grade has markedly decreased due to the entrainment of fine slime particles.

Effects of Conditioning Time

As may be observed from Figure 9 (Tests 38-41), the conditioning time varies between 10 and 13 minutes. The grade and recovery markedly decreases beyond 13 minutes conditioning time, due to the dissolution of Copper Xanthate ions in the equilibrium system. (Khan et. al. 1984).

FLOTATION TESTS FOR BULK ROUGHING-II

The Bulk Roughing-I tailings still contained 30% of the total copper. Therefore, to enhance the recovery of copper, the Bulk Roughing-I tailings

Flotation Process Parameters Investigated for bulk Roughing II

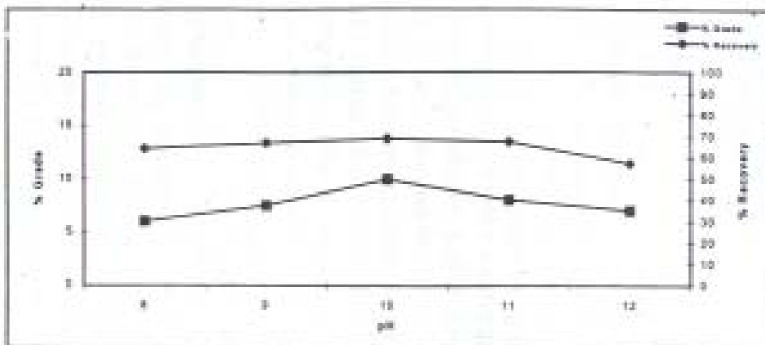


Figure.10 Effect of pH on Grade and Recovery of Copper

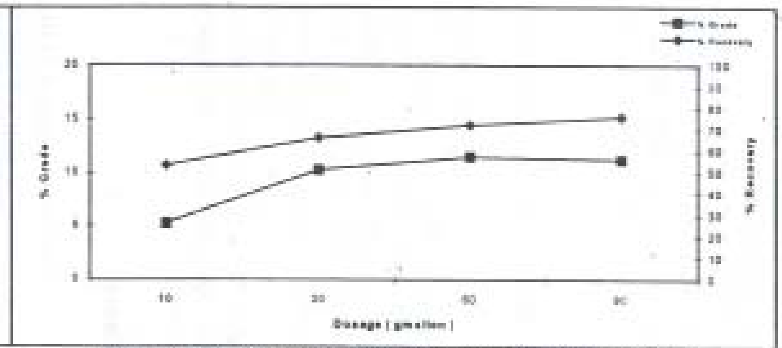


Figure.13 Effect of Collector (NaEX) on Grade and Recovery of Copper

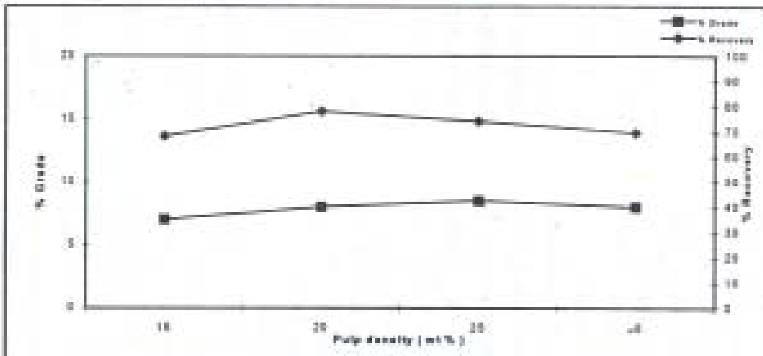


Figure. 11 Effect of Pulp density on Grade and Recovery of Copper

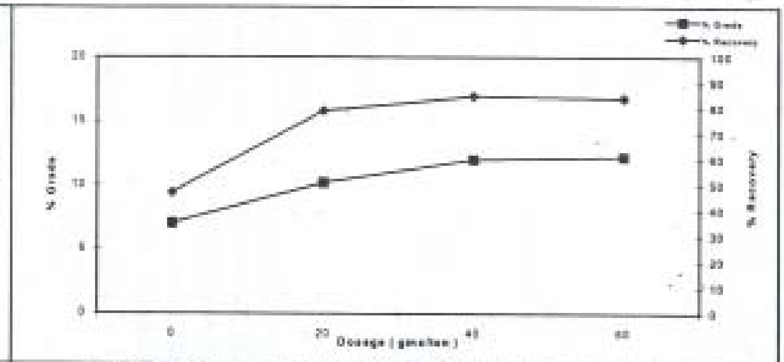


Figure. 14 Effect of Frother (Pine Oil) on Grade and Recovery of Copper

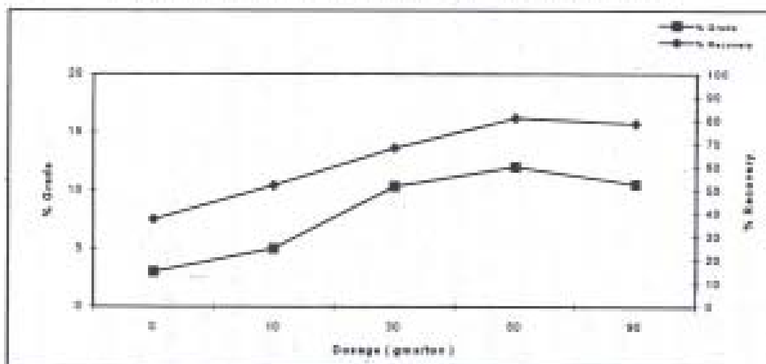


Figure. 12 Effect of Collector (NaPX) Grade and Recovery on Copper

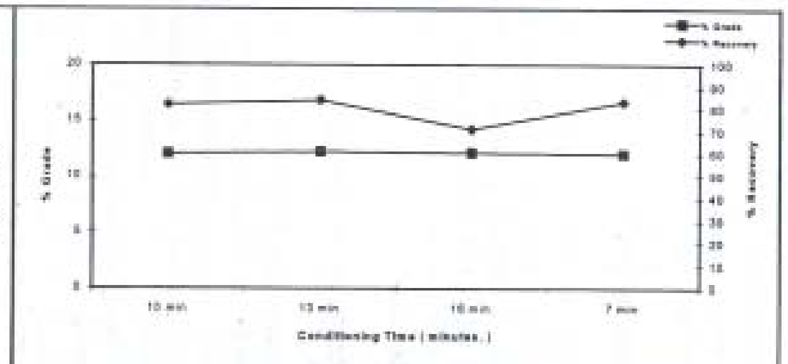


Figure. 15 Effect of Conditioning time on Grade and Recovery of Copper

were refloated in the 2nd stage (Bulk Roughing-II). The flotation parameters investigated in Bulk Roughing-II were pH; collector type and dosage; frother dosage; and conditioning time (Table 2).

Details of Tests

The effect of pH on grade and recovery of copper was investigated by varying the pH value between 8 and 12. Similarly, tests were also conducted to investigate the effect of pulp density; collector type and dosage; frother dosage and conditioning time (Table 2).

Discussion of Results

The curves in Figures 10-15 reveal the behavior of parameters investigated in the Bulk Roughing-II. In these tests, no activator (Na_2S) and depressant (NaCN) were used, as it was reasonably assumed that most of the oxidized copper minerals have been sufficiently sulphidized due to Na_2S addition in the Bulk Roughing-I. Similarly a considerable amount of free Iron and pyrite have been depressed in the same stage by the NaCN addition. Any small amount of Iron, if still existing in the pulp, could be depressed by caustic soda (NaOH) added as pH-regulator in this stage. In conducting tests for investigating the effect of pH, the pulp density and collector dosage were kept constant (Table 2). Better results were obtained at the pH of 10. This decrease in pH value may be attributed to low dosages of collectors used in these tests, as compared to the same type of test performed in the first cycle of flotation (Work and Cox, 1934). The best pulp-density is between 22 and 25%, as can be seen in Figure 11. No doubt, the range is comparatively lower than that observed in Bulk Roughing-I. This confirms why it is a normal practice to decrease the pulp-density in secondary roughing and cleaning operations of the flotation circuits in mineral-processing plants. Although it increases the cost of dewatering the concentrate, but it does improve the overall metallurgical output (Wills, 1985). Two types of xanthates were tested in a total of nine tests. The response of NaPX was better than NaEX, which may be due to the fact that xanthates of higher homologous series are more efficient in the absence of any activator (Wark and Cox, 1937). Of the total number of tests conducted, the best results for pine-oil (frother) were observed at 46 gms/ton. Conditioning-time was also varied, at an incremental value of 3, from 7 to 16 minutes. Considering the Figure 15, it is clear that the conditioning time of 10 minutes is better, both in respect of quality and cost of concentrate.

FLOTATION TESTS FOR CLEANING-I

The concentrates from the Bulk Roughing-I and Bulk Roughing-II were cleaned to get the cocentrate of desired grade. The objective of the cleaning stage is to produce a smelter's grade concentrate by refloating the concentrates from the roughing sections (Lindgren and Broman, 1976). The parameters investigated during this stage were pH value; dispersent dosage (Sodium Silicate); collector type and dosage; pulp density and conditioning time.

Details of Tests

Five parameters were investigated in this cycle of flotation (Figures 16-21). According to the results of the tests, the recovery improved by almost 40% as the pH increased from 8.5 to 9.2. This. pH value may be relatively low, as compared to Bulk Roughing-I flotation cycle, due to the decrease in the concentration of collector (Work and Cox, 1934) and lower pulp-density (20%) maintained for these tests. Sodium Silicate usage further enhanced the grade and recovery. This may be due to the dispersive effect of Sodium Silicate on the coagulated slime particles (Fe-hydroxides precipitates or oxidised sulphide particles) (Smart, 1991) formed on copper sulphide mineral particles. The response of NaAmX was better than NaEX, which may be due to its stronger collecting action on the particles. In the previous tests in this cycle of flotation, the pulp density was maintained at 20%. However reducing it to 15% did improve the output of the concentrate, in terms of grade and recovery. Cleaner separations are obtained with dilute pulps, in order to increase selectivity (Poling, 1980). The effect of conditioning time was negligible in the range of 5-8 minutes. Hence minimum time of conditioning (5 minutes) was considered suitable (Figure 21).

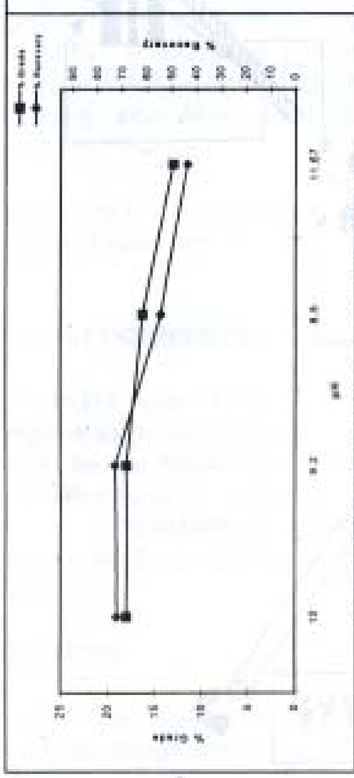


Figure. 16 Effect of pH on Grade and Recovery of Copper

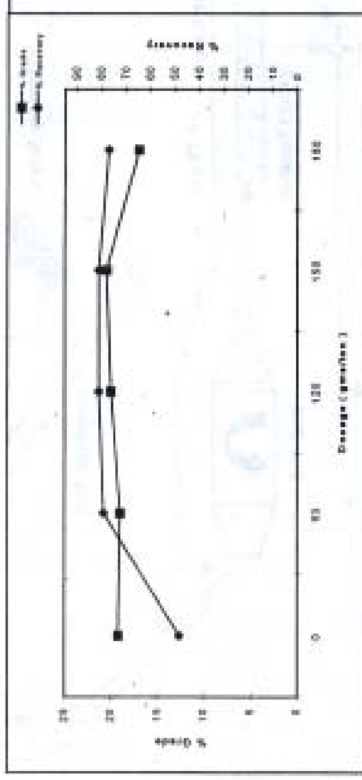


Figure.17 Effect of depressant on Grade and Recovery of Copper

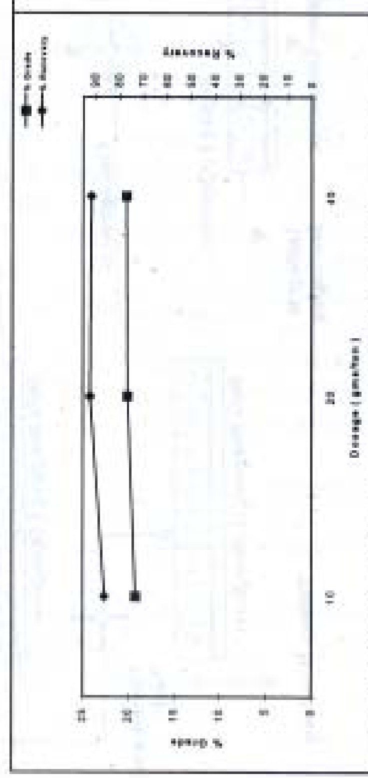


Figure. 18 Effect of Collector Dosage (NaEX) on Grade and Recovery of Copper

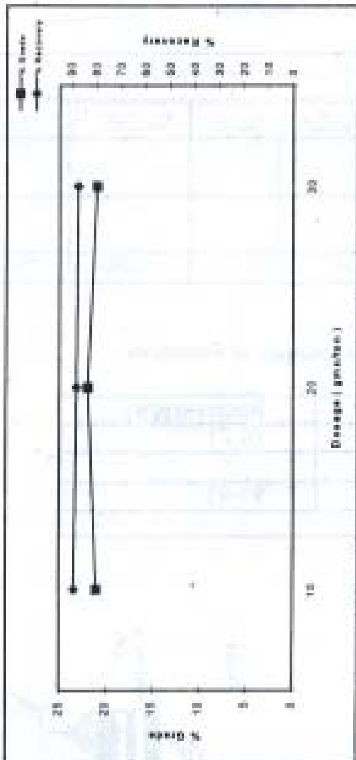


Figure. 19 Effect of Collector (NaAmX) on Grade and Recovery of Copper

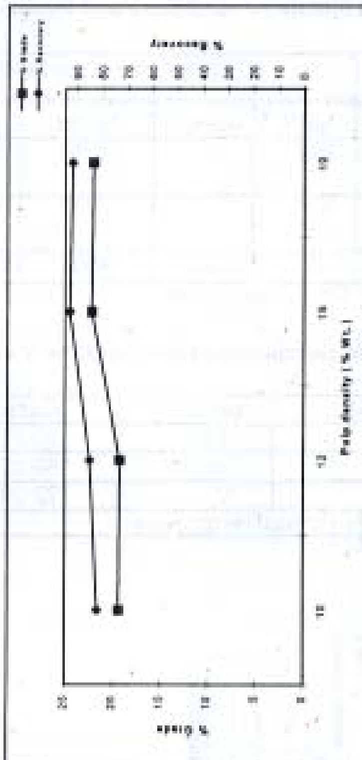


Figure. 20 Effect of pulp density on Grade and Recovery of Copper

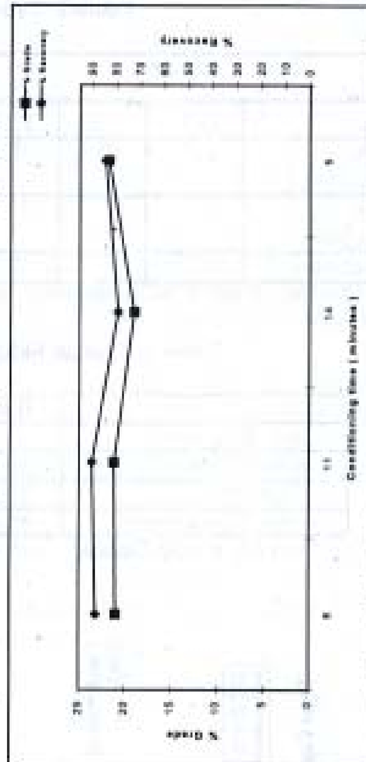


Figure. 21 Effect of Conditioning time on Grade and Recovery of Copper

Table 2. Typical Flotation Conditions and Reagent Consumption

Time (in minutes)				Flotation Reagents (gms/ton)						
	G.T.	C.T	F.t	NaPX	NaAmX	NaOH	NaCN	Na_2S	Na_2SiO_3	Pine Oil
Bulk Roughing-I	20	10	12-15	200	--	2200	25	50	--	46
Bulk Roughing-II	--	8	12	60	--	1100	--	--	--	46
Cleaning-I	--	5	12	--	20	800	--	--	150	35

G.t=Grinding Time, C.t=Conditioning Time, F.t=Flotation Time

Table 3. Typical Flotation Conditions and Results for Various Stages of Flotation

	P.d (%)	pH	Cu(%)	Recovery(%)
Bulk Roughing-I	30	11.58	20-21	70-71
Bulk Roughing-II 25	10	13-13.5	80-83	
Cleaning-I	15	10	22-23	91-93
Final Concentrate	81-83% cumulative recovery			

P.d (%) = Pulp Density

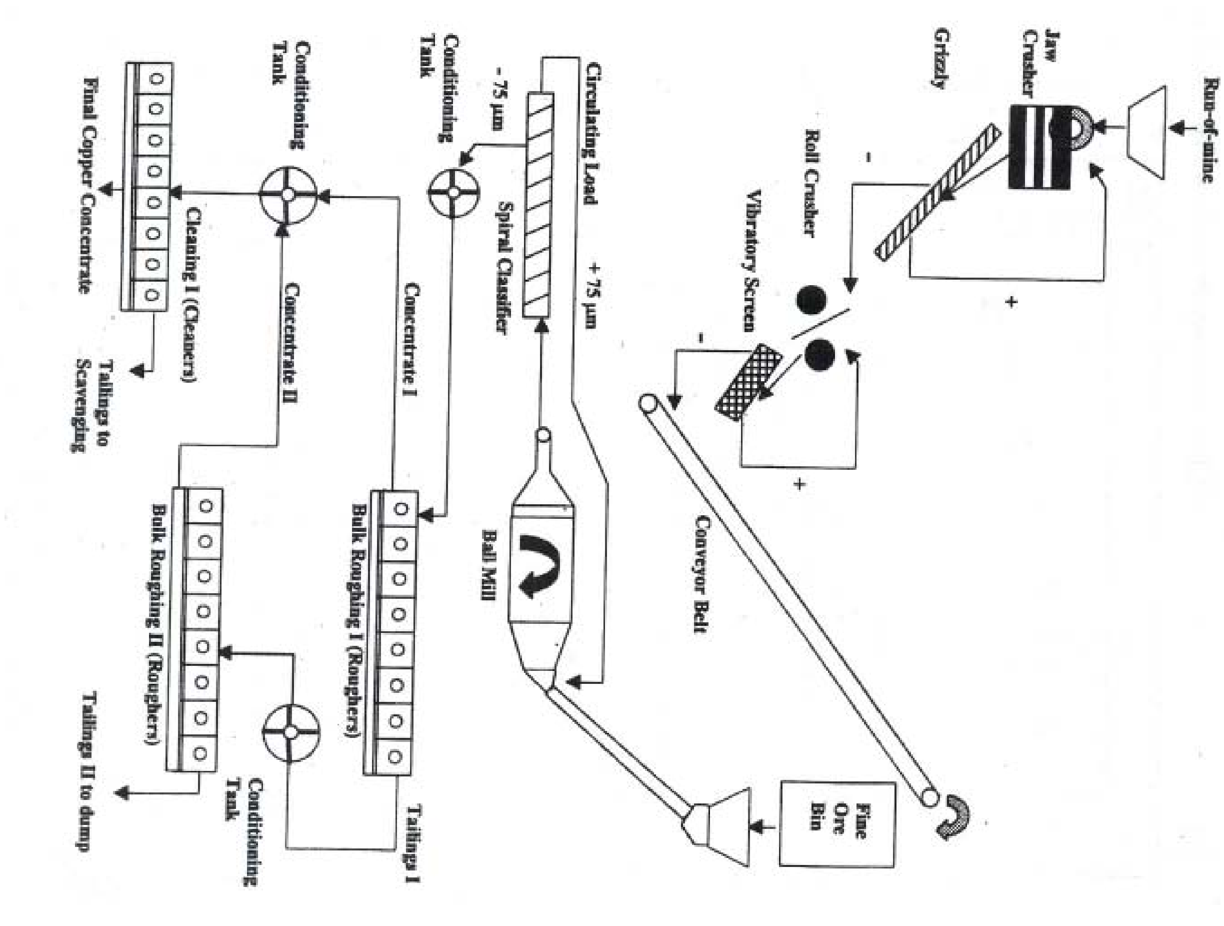


Fig. 22 Flowsheet for Copper Concentration at the Mineral Concentration Pilot Plant

SUMMARY AND CONCLUSIONS

The results obtained in these pilot-scale studies indicate that it is possible to achieve good separation of copper from the gangue material. The nature of copper-bearing minerals (such as azurite, malachite) and gangue is such that it has insignificant effect on the selective physico-chemical separation of major copper-bearing mineral (chalcopyrite). Taking into account the nature of the ore, the upgradation achieved is quite satisfactory. The collector-dosage needs to be investigated, to reduce its consumption, especially in the Bulk Roughing-I cycle. Moreover, to further reduce the cost of treatment, the effect of lime should be studied, in place of caustic soda, because of its lower cost. The grade of copper-concentrate obtained through single-stage cleaning is 22%. However, it can be further improved by incorporating supplementary cleaning-stages in the basic flowsheet, as is being practiced in copperflotation circuits internationally e.g. Afton Copper Concentrator in Canada (World Mining, 1978) and Pyhasalmi flotation circuit in Finland (Wills, 1983). A proposed flowsheet of copper concentrator prepared by the Department of Mining Engineering, after these pilot-scale studies, is presented in Figure 22.

The parameters established as a result of pilot-scale studies are summarised in Tables 2 & 3.

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HUMAN AGE DISTRIBUTION; A SAMPLE SURVEY

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ABSTRACT

A statistical investigation is made of the life spans of adult human beings of the previous two centuries, to look into their pattern of mortality. The life span, or age-distribution is revealed to be quadri-modal in nature, refuting the prevailing myth that all ages are equally susceptible to death. The major peaks of mortality, are found to be at 57,68,77 and 86 years, respectively.

INTRODUCTION

"Every soul will/must taste of death...." [Al Quran, 3.185, 21.35, 29.57]. These are the words, the Holy Quran uses to explain that every human being on the face of earth is to die. But when? At what age? Are all ages equally susceptible to death? If not, which are the ages that are more, or less, susceptible? Is it possible that a trend, or a probablity distribution, can be observed for the ages, that can be used fo rprediction and forecasting? These are the questions that are being asked and partially answered in this article.

Human life and age has always been the centre of research. How can it be made long? How can the process of aging be delayed? Research Literature is replete with all sorts of struggles to de-engimatize these and related issues. But little is available to study human age with reference to forecasting, or a predictable, trend or probability-distribution for human age. Even the basic sources of such research, like Encyclopaedia Britannica, and Encyclopaedia Americana do not have any direct, or even indirect reference to this facet of human age. Qurashi & Shah [1983 & 1984], however, made attempts to model the creative span, total life-span, and month of expiry of early Muslim scientists and some eminent Pakistani scientists of the last hundred years. A similar analysis was later made by Qurashi [1993] for 31 eminent Pakistan scientists who died between 1970 and 1992.

The present author conducted a preliminary sample-survey in an attempt investigate more fully the relationship between human age and occurence of death. The survey unveils certain more susceptible-to-death ages and contrives a possible trend for some rough "prediction" about death.

The Hypothesis

"All ages are not equally vulnerable to death": this is a general statement. It has already been established that infant mortality, child mortality and adult mortality rates are significantly different, so the scope of this hypothesis is reduced to adult mortality only. The qualified hypothesis is thus stated as: "all ages beyond 30 years are not equally vulnerable to death".

METHODOLOGY

A sample of 5,000 celebrities, of the previous two centuries, from five different professions, i.e. show-business (named category # 1 - say C1), medicine (named category # 2- say C2), academics (named category # 3 - say C3), science (named category # 4 - say C4), and law (named category # 5 - say C5), is taken from different sources, like Encyclopaedia Britannica (1993, 94, 95, 96, 97, 98), Encyclopaedia Americana (1992, 93, 95, 96, 97, 98), Macmillan Encyclopaedia (1994), Encarta Multimedia Encyclopaedia 98, Groller Multimedia Encyclopaedia 98, and their dates of birth and death are recorded to study their ages. These celebrities are then classified into five classes, according to the five specified categories, such that each class has about 1,000 celebrities. Then 26 strata are made, for each of the 5 classes, according to 26 alphabetic characters (A through Z). A simple random sample is, then, selected from each stratum of a size proportional to the available celebrities in the stratum, so as to have a sample of size 60 for the particular class.

Thus, five proportional stratified random samples of 60 celebrities each, of the previous two centuries, and of five different categories are the result. It is thought that the results on the celebrities can be generalized for all human beings. In the following elucidation, some proof for this point shall also be provided. Furthermore, the celebrities who have been murdered or had an unnatural death are not included.

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This exclusion has to be taken, as the rate of being murdered in celebrities is understandably quite high, as compared to common populace.

Following are the compiled results of this recording, giving the number of celebrities dying in different age-groups at intervals of 5 years. The last column gives the number of deaths recorded from a corresponding sample taken from all of the 5,000 selected celebrities.

Table 1. Data on Life-Span for Five Different Categoires of Celebrities

Age Groups	C1	C2	C3	C4	C5	Whole
Less than 30	1	1	0	0	0	1
31-35	1	3	0	0	0	2
36-40	0	3	1	1	1	2
41-45	1	1	1	1	1	1
46-50	1	1	2	2	4	2
51-55	2	3	1	5	6	3
56-60	7	1	5	9	4	5
61-65	2	5	6	0	1	2
66-70	9	7	12	7	10	9
71-75	7	12	7	8	6	7
76-80	13	8	9	10	7	9
81-85	9	5	5	8	7	7
86-90	5	7	7	7	9	7
91-95	1	1	2	1	4	2
Above 95	1	2	2	1	0	1
Total	60	60	60	60	60	60

A shaded area frequency-curve (contrived with the help of MS Excel 97) for this table, giving a cummulative effect for all the categories is shown in Fig.1.

Here are some of the main features of the above shaded-area frequency-curve, drawn for Table 1:-

1. All classes of the celebrities behave almost identically, as the up-down formation is almost identical for all the individual curves of the composite. In other words, the death-pattern in all the investigated five professions is almost the same. So, it can be said that the age at death is indifferent to profession.
2. Numbers of celebrities dying in different age-groups are not the same and all classes of celebrities are corroborating this fact. This is establishing the considered hypothesis that all ages are not equally vulnerable to death.
3. Thorny peaks are observed for some age groups (especially for the groups (56-60), (66-70), (76-80) and (86-90)) where most of the classes show abnormal conic pattern, indicating a high vulnerability for deaths at these ages.
4. These peaks are observed for approximately the same age-groups in all the five classes.
5. There are some relatively safe ages, especially in between the thorny peaks.

So, it can be inferred that the human age is not equally distributed over all age-groups, beyond 30 years, but there are some groups that are more vulnerable than others. This characteristic is observed in all the five categories of celebrities. As the death-pattern is indifferent to the profession - as estblished in above stated feature # 1, so the results may easily be extended and applied to common populace.

To eradicate the grouping error in the data, let us arrange the data again in age groups with a difference of four years, instead of five years. The following are the results, which show maxima identical with those in Table 1:

Table 2. Frequency Distribution of Ages of Celebrities of Five Different Fields (Group Difference is 4 years)

Age Groups	C1	C2	C3	C4	C5	Whole
Less than 30	1	1	0	0	0	1
31-34	1	2	0	0	0	1
35-38	0	4	1	0	1	2
39-42	1	0	1	0	2	1
43-46	1	1	1	0	1	1
47-50	2	1	2	2	3	2
51-54	3	4	1	5	6	3
55-58	4	2	5	7	3	4
59-62	1	1	3	2	2	2
63-66	1	4	5	1	2	5
67-70	8	7	10	8	8	6
71-74	7	10	6	7	6	8
75-78	9	5	4	10	5	7
79-82	8	4	7	4	5	6
83-86	7	6	5	9	6	4
87-90	4	5	5	3	7	5
91-94	1	1	2	1	3	1
95-	1	2	2	1	0	1
Total	60	60	60	60	60	60

CONCLUSION

Explicity, the modified frequency-distribution, and the corresponding shadedarea frequency-curve, for human ages tells the same story as for the graph with an age difference of five year between groups. Again, there are four thorny peaks observedfor almost the same age- groups, or ages, as indicated in the

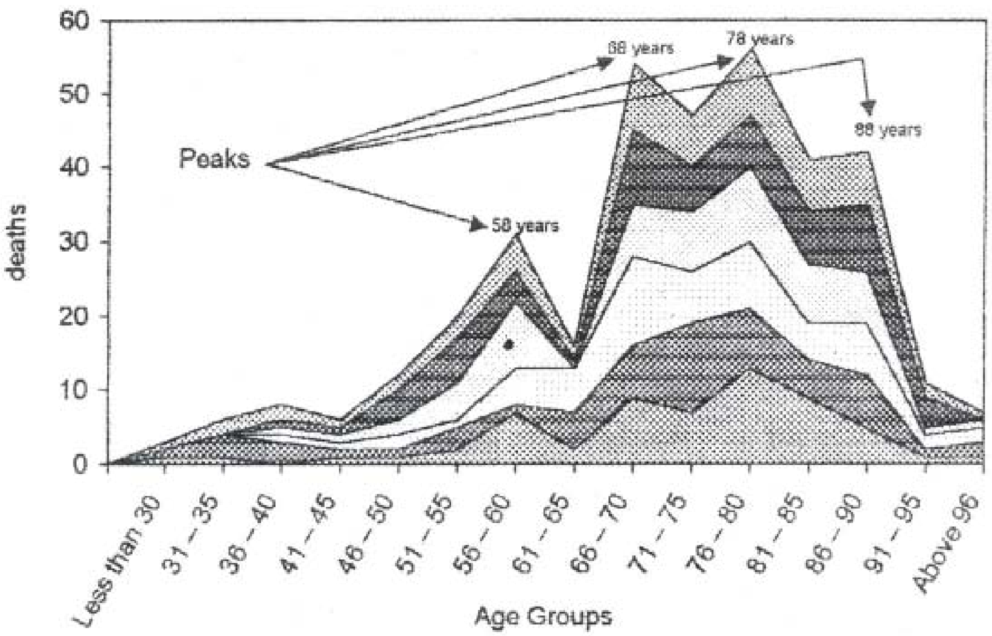

Fig.1 Shaded Area Frequency-Curve for the Ages, when the Group Difference is 5 years. Thorny Peaks are indicated

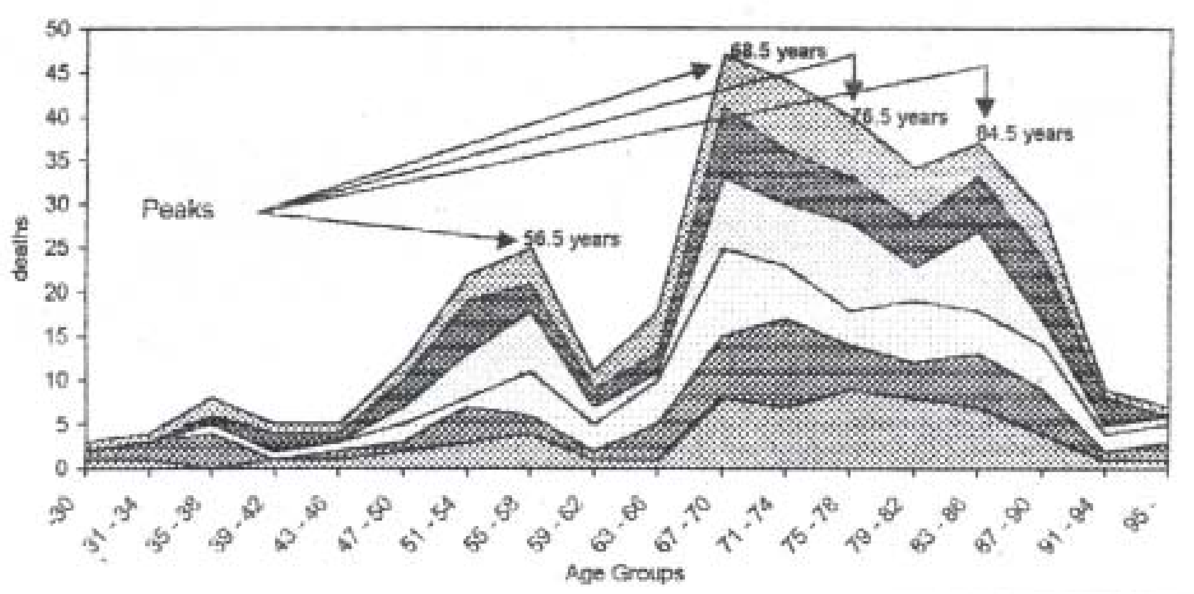

Fig.2 Shaded Area Frequency-Curve for the Ages, when the Group Difference is 4 years, with Thorny Peaks indicated

Fig. 2. This is shown in Table 3, below:-

Table 3. Comparison of 4 Major Thorny Peaks, giving ages with maximum vulnerability to death

	Position of Thorny Peak (in years)			
	Peak1	Peak2	Peak 3	Peak 4
Group Difference = 5 years (Fig.1)	58	68	78	88
Group Difference = 4 years (Fig. 2)	56 1/2	68 1/2	76 1/2	84 1/2
Means	57 1/4	68 1/4	77 1/4	86 1/4

Note: There are traces of a small peak around 37 years in both Figs. 1&2, as also another one around 100 years.

This survey was conducted to look into the veracity of a prevalent myth that the chances of dying are equal at all ages, especially beyond 30 years. The survey revealed that these chances are not equal, but some ages are considerably more vulnerable to death and some are less. These ages for high vulnerability can now be given as 57±1, 68, 77±1, and 86±1 years (refer to Table 3, above) for these four major peaks identified in the present analysis.

These compare with the peaks found in an earlier analysis of a small sample of eminent Pakistani scientists (died between 1970 and 1992) published by Qurashi [1993], which were at 51 years, 63 years, 77 years, and ~85 years. Giving agreement to within ±3 years on the average, this data tends to confirm further our hypothesis that persons at these special ages are highly susceptible to death. Further statistical and physiological studies should be of interest.

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INTERFACIAL DEBONDING OF NATURAL-FIBRE REINFORCED COMPOSITES

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ABSTRACT

The mechanisms and processes involved in interfacial debonding and fracture of natural fibre reinforced composites (NFRC) have been investigated. The Pullout theory, which depends upon factors such as lateral deformation, Poisson's effect and non-uniformity of fibres, was used to determine the fracture-toughness. It was observed that the total fracture-energy is a contribution from the surface energy, redistribution energy and pull-out energy, while the surface-energy term originates from the creation of three new surface-energy terms (fibre, matrix and fibre-matrix interface). The fracture-mode is complex, as it involves fibre-splitting, decohesion, crack-formation and propagation.

Using Eshelby's equivalent-inclusion method, the transition-stresses between the three stages of stress-strain curves were predicted. The first stage of the curve is linear and indicates that bonding of matrix-interface is essentially perfect and both phases deform elastically. The second and third stages are non-linear. During the second stage, microcracks are initiated from fibre-ends and extend to the matrix. In the third stage, the microcracks become abundant, interlink or coalesce into macrocracks, which propagate to fracture. The transition from second to third stage occurs when the crack extends further in the matrix and propagates as a Griffith-type crack.

The propagation of stress-corrosion cracks in aligned NFRC were also investigated by using the concept of strain-energy release-rate, as primary parameter, to derive values of stress-intensity factor for plane strain.

INTRODUCTION

The manufacture and use of improved natural-fibre-reinforced composites have not been commercialized on a large scale in Ghana, and there is an urgent need to improve upon the physical, chemical and engineering properties of these natural composites, so as to facilitate easier fabrication and prolong their service-life, since there are unique advantages to be gained by developing new and sophisticated uses of the natural-fibre composites. The fibres are readily available and renewable, and their extraction and processing into composite materials require simple techniques and minimum input of energy. Due to their low density, these fibres can be used to produce composites with high specific strength. In addition, the natural fibres are non-toxic and are also environmentally degradable.

Unfortunately, the epidermis of the fibre has a thin layer of silica at its outer surface, which inhibits good bond-formation with polyester resins. Caustic soda or ammonia can remove the silica-rich layer, to improve surface adhesion. Alternatively, the fibre could be mechanically crushed, by rolling, to improve the fibre-to-resin bond, reduce porosity and air-content of the parenchyma and lumen, shear the hard epidermis, thus allowing easy penetration of the resins and other binders to the softer tissues beneath.

The binders or matrix materials used can be categorized as polymer-based, laterite-based and concrete-based (with additive of ash to decrease the weight). The common polymer binders are elastomers, wood glues, latex, natural and commercial resins. The most common natural fibre reinforced composites (NFRC) produced in Ghana are polymeric and concrete based.

By incorporating strong, stiff and brittle natural fibres into a softer or more ductile matrix, the NFRC material produced would have improved strength, fatigue-resistance, stiffness and high strength-to-weight ratio [1-7]. the matrix material transmits the force to the fibres and provides ductility and toughness, while the fibres carry most of the applied force. The fibre-reinforcing materials can be arranged in a variety of orientations, such as, uni-directional, randomly oriented, orthogonal and multiple-ply. In this paper, the complex nature of misoriented short-fibre composite interfacial-debonding and fracture is

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discussed, since the understanding of such a structure-sensitive property is essential for material design and applications.

POLYMERIC NATURAL-FIBRE REINFORCED COMPOSITES (NFRC)

The polymeric NFRC produced in Ghana are based on thermosetting phenolic, epoxy and polyester resins as binders, to produce straw-polyester composites, bagasse-phenol formaldehyde composites, coir-polyester composites, plantain/banana-polyester composites, pineapple- andsisal- epoxy composites and jute-epoxy/polyester/phenol formaldehyde composites. The fibres are produced by manual picking and are processed with the matrix by either pressmoulding or hand lay-up. Table 1 shows data on physical properties of various fibre-polyester resin composites, while Table 2 shows data on environmental degradation of fibre-reinforced composites [8]. Tables 1 and 2 deserve careful study, as they show that mechanical properties of NFRC are lower than glass-fibre reinforced composites (GFRC) under normal and adverse conditions. The reason for the discrepancy can be attributed to the poor bonding of natural fibres to the matrix and this phenomenon is the main subject of this paper.

NATURAL FIBRE CONCRETE

Natural fibre-concrete (NFC) is basically made of sand, cement, fibres and water, and is used mainly in the production of corrugated sheets and pantiles for roofing in low-cost construction. The plant fibres used are stems (jute, kenaf, hemp), leaves (sisal, pineapple, raffia, palm), fruit hair (coir) and wood fibres (reeds, bagasse, bamboo).

The fibre content (1-2% by weight) is required primarily to hold togther the wet mix during manufacture, to inhibit drying shrinkage-cracking and to provide early strength until the roof is installed [9]. In normal Portland-cement matrices, the fibres decay within months or a few years on account of alkali attack. This alkaline attack can be minimised by using high-alumina cement or replacing 50 % of the cement with pozzolana.

FIBRE-MATRIX INTERFACIAL DEBONDING

Interface bonding and debonding of NFRC is a structure-sensitive properly, which must be evaluated to determine the compatibility of fibres with matrices. Natural fibres are themselves fibre-reinforced materials and the microfibril angle and cellulose content determine their mechanical behaviour [10].

The effectiveness of the fibre-matrix bond is dependent on the chemical compatibility and the presence of mechanical "keying" between the fibre and matrix. An irregular surface of the fibre is more likely to enhance the efficiency of fibre-matrix interfacial bond than "smooth ones, due to greater surface-area present at the interface. However, natural fibres contain waxes and fatty acid bye-products that are unlikely to form any chemical bonds between the fibre-surface and resin, thereby causing a weaker interfacial bond [1].

Natural fibres fail because, as the applied stress increases, the weak primary cell-wall collapses and decohesion of cells begins, following decohesion of cellulosic and non-cellulosic molecules (mainly through cracks and imperfections). The applied stress also causes the uncoiling as well as extension of the crystalline fibrils in the secondary cells-walls.

The fracture of NFRC, therefore, depends on the fibre-failure strain and matrix-failure strain resulting from viscoelastic behaviour. The failure of the fibres results from uncoiling of microfibril angle, accompanied by decohesion and tearing of cell walls. The fracture-mechanics of the Pullout theory and Eshelby's equivalent-inclusion theory were applied in order to study the processes involved in fibre-matrix interfacial debonding of NFRC. The work of fibre-pullout energy, which depends upon factors such as lateral deformation, Poisson’s effect and non-uniformity of fibres, was used to determine the fracture toughness of the composites. The Eshelby’s equivalent-inclusion method was used to predict the transition-stresses, at which interfacial debonding takes place.

Figure 1 shows typical stress strain curves of a natural fibre and NFRC. The low strength characteristics of the NFRC, compared with the single fibres can be attributed to lack of compatibility and debonding. By the rule of mixtures (ROM), the strength of NFRC is given as

Table 1. Properties of various fibre-polyester resin composites [8]

Property	Polyester Resin (0%, V_F)	Glass Reinforced Polyester Resin (unknown % fibre)	Banana Reinforced Polyester Resin (11Wt % Fibre)	Coir Reinforced Polyester Resin (9 Wt % Fibre)
Density x 10^3 (kgm^{-3})	1.30	1.50 - 1.90	1.22	1.16
Tensile strength (MPa)	41.38	241.4 - 689.6	27.96	18.61
Flexural strength (MPa)	89.69	344.8 - 862.1	64.00	38.15
Elastic modulus (GPa)	2.06	6.90 - 41.38	3.34	4.05
Impact resistance (kJm-2)	7.75	31.16 - 84.76	329.2	39.10
Water absorption (%*)	0.21-0.40	0.2 - 1.0	1.36	1.36
Volume resistivity (Ω-m)+	1000	--	400	--

* 24 hour soaking at room temperature + At 100 V(dc)

Table 2. Environmental effect on physical properties of fibre-reinforced composites, before and after weathering for seven years [8].

Physical Property	Unweathered Jute-Fibre Reinforced	Weathered Jute-Fibre Reinforced
Bulk density x 10^3 (kgm^{-3})	1.150	1.025
Fibre content (%)	12 - 15	--
Water absorption % (25^oC)		
(a) 24 hours	2.34	3.23
(b) 3 days	2.88	4.16
(c) 7 days	3.87	5.07
Water absorption % (100^oC, 1 hour)	3.08	3.90
Flexural strength (MPa)		
(a) Dry	23.00	11.60
(b) 24 hour soaking	32.10	28.20
(c) 3 days soaking	42.60	19.60
(d) 7 days soaking	34.00	19.10
Tensile strength (MPa)	24.20	14.8

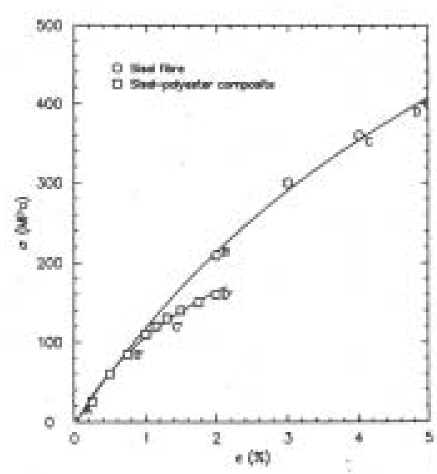

Fig. 1: Typical stress-strain curves of a sisal fibre and NFRC, showing transition stage at B,C,B' and C' respectively.

$$\sigma_c = \sigma_f V_f + \sigma_m\ (1 - V_f) \quad \textbf{(1)}$$

where σ_c and σ_f are the composite and ultimate fibre-strength, respectively; and σ_m is the stress taken up by the matrix at the failure-strain of the fibres (ε_f) and is given as $E_m\varepsilon_f$. Similarly, for the tensile modulus,

$$E_c = V_f\ E_f\ \ (1 - V_f)E_m \quad \textbf{(2)}$$

where E_c, E_f and E_m are the initial tensile moduli of the composite, fibre and matrix, respectively.

PULL-OUT THEORY OF FIBRE-MATRIX INTERFACIAL DEBONDING

The Pullout theory assumes that the fibres break due to presence of flaws that are randomly distributed, and in the absence of this randomness the fibres will break in the crack-plane and no pull-out will occur [7]. The Pullout theory can be used to determine the fracture-toughness, in terms of the volume fraction, V_f, fracture critical length, l_c, diameter, d_f, tensile modulus, E_f, failure strength, σ_f, of the fibres, and the interfacial frictional shear strength (τ_f). The fracture mode of NFRC is complex, since it invovles fibre-splitting, decohesion, crack-formation and propagation and other energy-absorbing machanisms.

The fracture critical-length is calculated by assuming that the average pullout length. T_p, is half the maximum attainable pullout length and, therefore, the interfacial fricional shear strength can be obtained from the Kelly-Cottrel equation [11].

$$\tau_f = \frac{\sigma_f d_f}{2l_c} \quad \textbf{(3)}$$

The fracture toughness can be predicted from contributions of the total work of fracture, W_T, by summing the contributions of all sources of fracture-mechanisms involved [12]; namely, the surface-energy term, W_S, the redistribution-energy term, W_R, and the pullout-energy term, W_P:

$$W_T = W_S + W_R + W_P \quad \textbf{(4)}$$

where [13, 14]

$$W_R = \frac{V_f\ \sigma_f + d_f}{6E_f\tau_f}\ ,\quad W_P = \frac{V_f\ \sigma_f\ d_f)}{24\tau_f} \quad \textbf{(5)}$$

The major contributions to the overall work of fracture of the composite are W_S and W_P. The surface-energy term originates from the creation of three new surfaces, namely; the fibre fracture energy, W_P; the matrix fracture energy, W_M; and the fibre-matrix interface energy W_I. The energy absorbed to create these new surfaces is give by [12]

$$W_S = W_M\ (1 - V_f) + W_F\ \ V_f + W_{IF} \quad \textbf{(6)}$$

where W_M is matrix-energy term (~1.365 kJm^{-2}), $W_F = ½\ \sigma_f\varepsilon_f l_d$ is the fibre fracture-energy term or energy absorbed in creating the fibre-fracture surface and l_d is the average debonded length (which is assumed to be of the order of l_C whereby $l_d \approx l_C$). The interface fracture-energy term, W_{IF} for mode I debond, where the fibre-fracture strain is less than matrix strain ($\varepsilon_f < \varepsilon_m$), is given by

$$W_{IF} = V_f\ \frac{l_c}{d_f} W_I \quad \textbf{(7)}$$

where W_I is the interface-energy term or interfacial fracture toughness. It is difficult to determine W_I but it can be approximated to be $\approx W_M$ since the matrix adheres to fracture-surface.

Usually, the debond length l_d is in the range of l_c such that $l_d \approx\ l_c \approx\ 4T_p$. If $l_d > l_c$ the predicted energy of the debonding, W_D (which is implicit in the surface-energy term), and the energy to fracture the fibre (W_F) would be affected. The fracture-toughness or energy increases linearly with fibre-content up to V_f = 0.24 [7]. As volume-fraction of fibre becomes higher than 0.24, fibre-fibre interactions would increase and cause changes in τ_f and l_c, which would lead to low values of debonding energy and fracture-toughness.

The expression deduced for W_T then becomes

$$W_T = W_M\ (1 - V_f) + W_F\ V_f + \frac{V_f\ l_c}{d} W_M + W_R + W_P \quad \textbf{(8)}$$

For resins, W_M =1.365 kJ/m^2, and eqn. (8) becomes

$$W_T = 1.365\left[1 + V_f\left(\frac{l_c}{d_f}-1\right)\right]½\ \sigma_f\varepsilon_f l_c V_f + \frac{V_f\sigma_f{}^3 d_f}{6E_f\tau_f} + \frac{V_f\sigma_f{}^2 d_f}{24\tau_f} \quad \textbf{(9)}$$

The experimental data obtained for sisal fibre were $l_f = 0.40$ mm, $d_f = 0.02$ mm, $V_f = 0.20$, $\varepsilon_f = 5\%$ $\sigma_f = 400$ MPa, $\tau_f = 0.70$ MPa and $l_c = 0.20$ mm, and these were used to calculate the contributions of each energy-absorbing mechanism, as shown in Table 3. For the NFRC, $\varepsilon_f = 2\%$ $\sigma_f = 160$ MPa.

The total fracture toughness or energy of 44.044 kJm^{-2} obtained by the Pullout theory is very high, as compared to typical experimental value of the work of fracture, W_{FE}, of 21.000 kJm^{-2} [7] determined by the Izod Impact Test for the NFRC. The difference could be attributed to the mode of specimen-preparation and testing conditions.

ESHELBY'S EQUIVALENT INCLUSION METHOD (EEIM)

Typical stress-strain curves of a fibre and a NFRC, characterized by an initial linear region and followed by a curvature, indicating the increased rate of strains produced with increases in stress are shown in Fig. 1,which confirm the viscoelastic behaviour of the materials as a two-element Maxwell model.

The first stage of $\sigma - \varepsilon$ curve is linear and indicates that bonding of matrix-interface is essentially perfect and that both phases deform elastically. The second and third stages are non-linear; the non-linearity is due to the initiation, development and extension of microcracks. During the second stage, microcracks are initiated from fibre ends and extend to the matrix. In the third stage, the microcracks become abundant, interlink or coalesce into macrocracks, which grow to a large size and propagate, leading to failure of the composite. The transitions at B' and C' in the stress-strain curves or the transition-stress between stage I (AB'), stage II (B'C') and stage III (C'D') of the $\sigma - \varepsilon$ deformation curve of short fibre reinforced composites can be correlated with the interfacial debonding.

As an analytical method, the EEIM can be used to predict the transition-stress, σ_1, between the first and second stages, where it is assumed that, while a majority of the fibres are randomly oriented as shown in Fig.2, a penny-shaped crack can be initiated from the end of a short-fibre which is aligned to the loading direction as illustrated in Fig.3. In addition, the critical stress, σ_2, necessary for the crack to propagate into the fibre as penetration type, or into the fibre-matrix interface as debonding type, could also be predicted.

TRANSITION STRESS, σ_1

The critical applied stress at which a penny-shaped crack arrested by adjacent fibres penetrates the fibres and the cumulative crack-density function were determined. Figure 2 shows the configuration of a randomly oriented short-fibre reinforced composite, showing both the global and local coordinates denoted by X_i and X'_i respectively. The applied stress, σ_0, along X_3 axis, can be decomposed into three components, $\sigma_{3'3} = \sigma_o^2 \cos^2\theta$, $\sigma_{2'2} = \sigma_0^2 \sin^2\theta$, and $\sigma_{23'} = \sigma_0 \sin\theta\cos\theta$, where the prime denotes the local coordinates attached to the fibre, and θ is the orientation angle of a short fibre with respect to the X_3 axis (loading direction). The short fibres shown in Fig.2 are assumed to be elongated ellipsoids of the same size and oriented randomly such that the composite material possesses transverse isotropy. The probability-density function, or the orientation factor, $g(\theta)$, is taken as [15]:

$$g(\theta) = 1/\alpha \ (0 \le \theta \le \alpha); \quad g(\theta) = 0 \ (\alpha \le \theta \le \pi/2) \qquad \textbf{(10)}$$

A plot of the orientation-factor versus orientation-angle is shown in Fig.4.

The transition stress, σ_1, between the first and second stages was calcualted for the condition at which the penny-shapped crack was initiated from the end of a short fibre which is aligned to the loading direction as shown in Fig.3(a). Toya and Mitra [16] have computed σ_1, for a completely aligned short-fibre composite. If the total free-energy of the composite, before and after the fibre-end crack is initiated, are U_1 and U_2 respectively, then to form a small penny-shaped crack at the fibre-end, the following inequality must be satisfied, $U_1 \ge U_2$. The inequality can be expressed as [13]:

$$\frac{8\sigma_0^2 (1 - \nu_m^2)(1 + \xi)c_1^3}{3E_m} \ge \pi c_1^2 \gamma_m \qquad \textbf{(11)}$$

where c_1 is the radius of the penny-shaped crack, and E_m, ν_m, and γ_m are the Young's modulus, Poisson's ratio and surface energy of the matrix, respectivley. The fibre-interaction parameter, ξ, is a function of elastic constants of the matrix and fibre, the fibre-aspect ratio and volume-fraction. It is also assumed

Table 3. Contribution of energy-absorbing mechanisms to debonding and fracture

NFRC	W_S (kJm^{-2})			W_P	W_R	W_T	W_{FE}
	W_M (kJm^{-2})	W_F (kJm^{-2})	W_{IF} (kJm^{-2})	(kJm^{-2})	(kJm^{-2})	(kJm^{-2})	(kJm^{-2})
$0.20V_f$	1.365	2.000	2.730	38.100	1.722	44.044	20.0-35.0

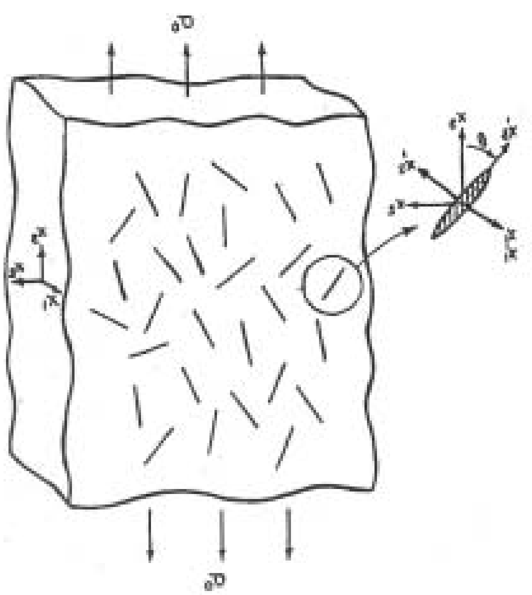

Fig.2: A schematic diagram of a randomly oriented short-fibre reinforced composite

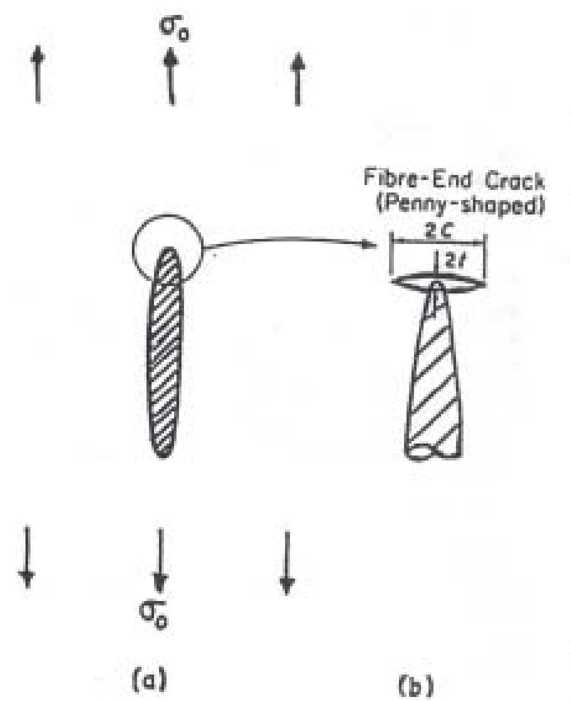

Fig.3: A crack-model for calculating the first transition stress

that the surface-energy term of the matrix-fibre interface, γ_1, is much smaller than that of γ_m. For completely aligned short fibre system,

$$\sigma_0 = \left[\frac{3\pi\, \gamma_m\, E_m^{½}}{8(1 - \nu_m^{\,2})(1 + \xi_1)c} \right] \quad (12)$$

To account for the random orientation of the short fibres, and by neglecting the shear and transverse-stress components, the effective applied stress for a short fibre, at an angle θ with respect to the X_3 axis, is $\sigma_o^{\,2}\cos^2\theta$. By replacing $\sigma_o^{\,2}$ with $\sigma_o^{\,2}\cos^2\theta$ and, considering the contribution of all misaligned fibres, the transition stress becomes:

$$\sigma_1 = h_1 \sqrt{\frac{3\pi\, \gamma_m\, E_m}{8(1 - \nu_m^{\,2})(1 + \xi_1)c_1}} \quad (13)$$

where h_1 is the orientation factor defined by [15]:

$$h_1 = \int_0^{\alpha} \cos^4\theta \,\frac{1}{\alpha}\, d\theta \quad (14)$$

TRANSITION STRESS, σ_2

The end of the stage II corresponds to the position when the crack, of radius, c_1 and c_2, is about to propagate as indicated by the solid line in Fig.5. Therefore, the transition from second stage to third stage occurs when the crack extends further into the matrix, and the critical stress σ_2 for the penny-shaped crack of radius c_1 and c_2 to propagate, as a Griffith-type crack, is [15]:

$$\sigma_2 = \sqrt{\frac{\pi\gamma_m\, E_m}{2(1 - \nu_m^{\,2})(c_1 + c_2)}} \quad (15)$$

The crack-propagation may be into the fibre (penetration type) or into the fibre-matrix interface (debonding type), and in either case may occur at a stress-level below σ_2, and hence it is feasible for the crack to extend into the matrix at the beginning of the σ–ε third stage of the curve.

COMPUTATION AND DATA-ANALYSIS

Consider a 20% short-fibre reinforced resin, with the following materials properties: *Matrix*: $E_m = 2x10^9$ Pa, $\nu_m = 0.42$, $\gamma_m = 1.356$ kJm^{-2}; Fibre: $E_f = 2x10^{10}$ Pa, $\nu_f = 0.20$, 1_f=0.40 mm, d_f=0.02mm; and *Composite*: Interfacial energy, γ_1 =2.730 kJm^{-2}, $c_1=d_f$, and $c_2=1.5d_f$ $g_1=E_R/E_A=0.73$, $\alpha \approx 30^o$, and h_1=0.8407 (where E_R and E_A are, respectively, the values of Young's modulus for composite with fibres arranged in random (R) and aligned to the loading (A)).

The predicted value of σ_1 is 133 MPa, as compared to experimental value of about 100 MPa, while the predicted value of σ_2 is 191 MPa, as compared to experimental value of about 160 MPa. As expected, the theoretical values are respectivley 33% and 20% higher than the experiemntal values; and these results follow the trend observed for the discrepancy in values of the total fracture-energy obtained by the Pullout theory (44.044 kJm^{-2}) as compared with the experimental value of work of fracture (21.000 kJm^{-2}). The two models indicate that stronger and tougher NFRC can be produced if properties of the materials and processing-technologies could be improved, since, the discrepancy in the resutls could be attribtued to poor bonding of matrix to fibre in the fabricated composites. Therefore, to produce NFRC of high performance, the composite must be designed with mininum imperfection, low stress concentrators, and very strong mechanical "keying" between fibre and matrix.

ENVIRONMENTAL EFFECT AND STRESS-CORROSION

Under the combined influence of stress and environment, NFRC may fail at much lower stress than in the absence of the environment. Spontaneous cracking of fibres in acids, in the absence of an extrenally applied stress, based on ion-exchange and leaching of material at crack-tip have been reported [17]. Crack-growth data can be used to predict lifetimes of components and the existence of inherent flaws in the material. The analyses of crack-growth in composite materials are based on strain-energy release-rate, G, as a primary parameter, from which values of stress-intensity factor for mode I opening, K_1, can be derived using the plane strain equation:

$$K_I^2 = \frac{EG}{(1 - \nu^2)} \quad (16)$$

where E and G are the Young's modulus and Poisson's ratio parallel to the fibres, respectively.

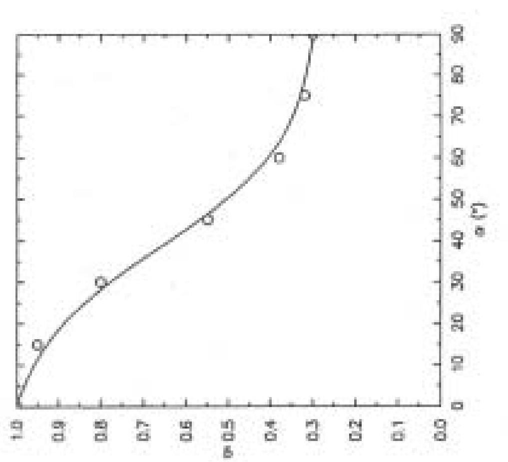

Fig.4: Plot of orientation factor versus orientation angle

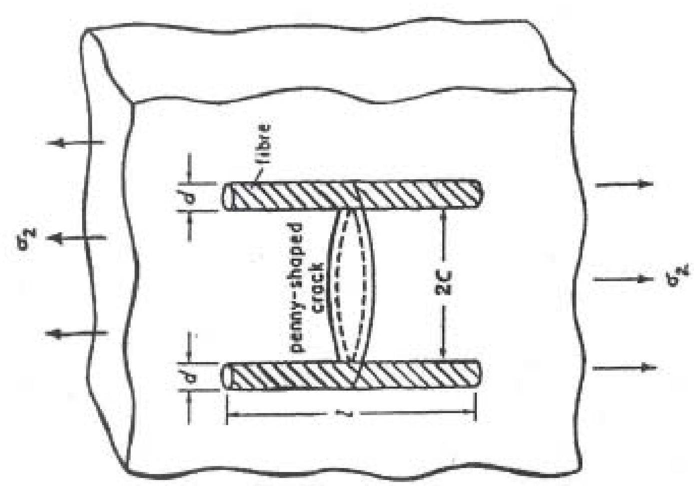

Fig.5: A crack-model for calculating the second transition stress

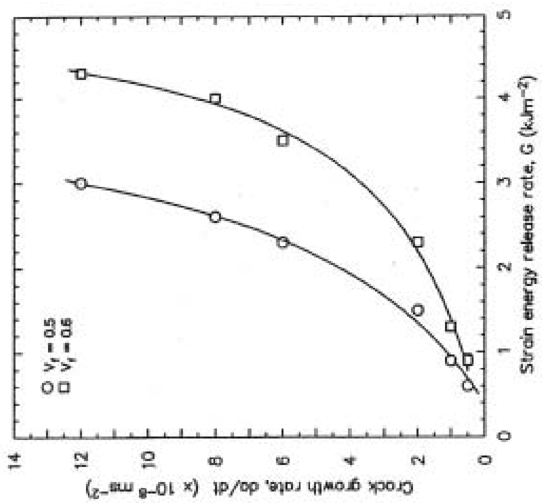

Fig.6: Effect of G on crack growth-rate for two values V_f

In NFRC, the crack growth is irregular, as the direction of the crack-growth and the shape of the crack-front varies considerably from point to point, and these changes are due to local variations in fibre-packing and indicate that crack-growth through the resin may have a significant effect on the overall crack growth-rate [18]. The average crack growth-rates in Fig.6 can be represented by the relationship:

$$\frac{da}{dt} = CK_I^n \qquad \textbf{(17)}$$

where C and n are constants. For $V_f = 0.6$, n = 3.6, while for $V_f = 0.5$, n = 4.2.

For direct comparison, it has been reported that da/dt in 0.6 N HCl is higher than in 1 N H_2SO_4 for a given K_1 [17]. The changes in appearance of the fracture-surface with increasing K_1 are consistent with the model for stress-corrosion cracking proposed by Hogg and Hull [18].

INTERFACIAL BONDING IMPROVEMENT

The two common methods of improving wettability of fibres in matrix are: chemical treatment and mechanical treatment. Caustic ammonia or soda will remove silica, while crushing the fibres increases surface-area for bonding. The cost of chemically removing the silica-rich layer at the surface of the epidermis, or plasticising the fibre, may outweigh any improvement in mechanical properties. To improve interfacial fibre-matrix bonding, wettability of fibre by resins must be studied. Fibres treated with solution of NaOH result in modification of surface, leading to increased wettability and minumum floatation and segregation of fibres in resins, since strong bonding improves mechanical properties. The chemical treatment causes the removal of cuticle and tyloses from the surface of the fibre, resultign in rought fibre-surface, with regualr spaced pits. Untreated fibres tended to float in the polyester, whereas alkali-treated fibres are uniformly dispersed in the matrix. The effects of alkali treatment on the microstructure, surface topography and tensile strength of fibre have been investigated [19], and the resutls confirm that the mechanical properties of coir polyester composites are improved by soaking the fibres in NaOH (3 weight %) for more than 72 hours.

DISCUSSION AND CONCLUSIONS

The benefits of using natural-fibre reinforced composites include, but are not limited to, improved plastic shrinkage, settlement cracking, low permeability, greater impact, abrasion, and shatter-resistance of the matrix material. However, it is clear that the problems of durability are associated with compatibility of fibres and matrix-material and environmental effect on stress-corrosion resulting from interfacial debonding.

The analysis of interfacial debonding, considered from the Pullout theory and Eshelby's equivalent method, can proivde basic mechanical data required for design of composite materials without expensive and time-consuming experimentation.

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LANDSLIDE HAZARDS AND POLICY-RESPONSE IN PAKISTAN: A CASE STUDY OF MURREE

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ABSTRACT

Like most parts of the world, Pakistan has been frequently subjected to a variety of natural hazards. Apart from the vast alluvial Indus plains, where people are mostly vulnerable to devastating floods and waterlogging, a major part of the country is mountainous and geomorphologically very active. It is here that people and their property are most vulnerable to various natural hazards, like earthquakes, landslides, flash floods and several others. Amongst these, the landslides and related failure processes are the most damaging because they are an ever-present and frequent danger for the people and their property. The main objective of this paper is to examine the impact of landslide hazard-reduction policies and their shortfall in Pakistan, with special reference to the important hill station of Murree, which is the worst slide-affected of the country.

INTRODUCTION

Murree, lovingly called "the Queen of the hills", lies in north latitude 33^o 54' 30" and east longitude 73^o 26' 30". It is the most easily accessible hill-station and sanatorium in Pakistan and is connected by a fine metalled road to Rawalpindi and Islamabad, at a distance of 61 and 51 Km respectively (Fig. 1). It is not only an administrative headquarter and commercial centre, but also the unofficial summer capital of the country.

Murree receives the highest amount of rainfall in Pakistan, averaging 66", with mean annual number of rainy days of 85 (Rabbani, 1986). It is located on a lateral spur of the sub-Himalayan mountains, with an elevation of 5,000-7,500 ft above seal level. This spur stretches at right angles to the plains, with general direction from north-east to south-west, and flanked on either side by parallel lines of hills. The Murree spur is composed of relatively young and geomorphologically fragile rocks, with hard grey-to-redish sandstone, predominantly interbedded with the soft and purple red calcareous shales. These rocks have the highest tendency towards landslides and related phenomena, specially in the presence of high, precipitation (Khan, 1992a, b; 1994).

This paper assesses and explains the current situation of the extent and causes of the increasing adverse effects of landslides in the area. After identifying major policies adopted by the government, the paper goes on to evaluate their impact towards the reduction of adverse effects of landslides.

DATA COLLECTION AND ANALYSIS

A variety of research techniques were used to collect the necessary data. Prior to the field work, a detailed reconnaissance survey was carried out to review the reports and available record at concerned organizations. Informal interviews and discussions were held with governemnt officials of the relevant departments and influential personnel in the area, in order to get information about the governemnt policies in this context. However, some of the data needed could only be collected from a household survey. Therefore, a sample household questionnaire-survey was undertaken with household heads, so as to elicit the required information for the evaluation of the policies adopted by the government for the reduction of landslide hazards (Khan, 1992a; 1994). For this purpose the city was divided into three areas, based on environmental characteristics, i.e. urbanization, location and people's occupation, etc. These areas were named as (i) Inner City (ii) Urban Fringe and (iii) Rural Fringe. The inner city is the main centre and commercial heart of the town, where people are mainly involved in retail activities. It includes the Station Area, Lower Bazaar, Shiwala, Agency area, Sunny Bank, Kuldana, Pindi Point and Kashmir Point (Fig. 2). The urban fringe includes Chitta More, Kashmiri Mohallah near Bansra Gali, Dhobi Ghat, Kashmiri Mohallah, Abbasi Mohallah (Gharan), and Dhok Jabar Topa, where people are mainly involved in retail, contracting and some farming activities. The rural fringe is semi-urbanized, and has influences of the rural environment. It includes Hill Dholu, Dhok

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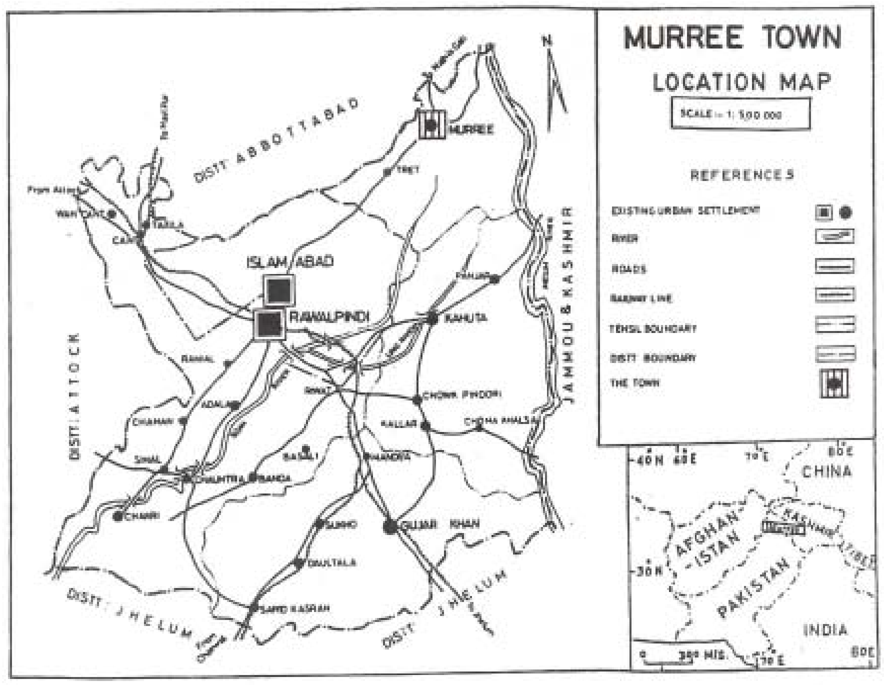

Figure 1

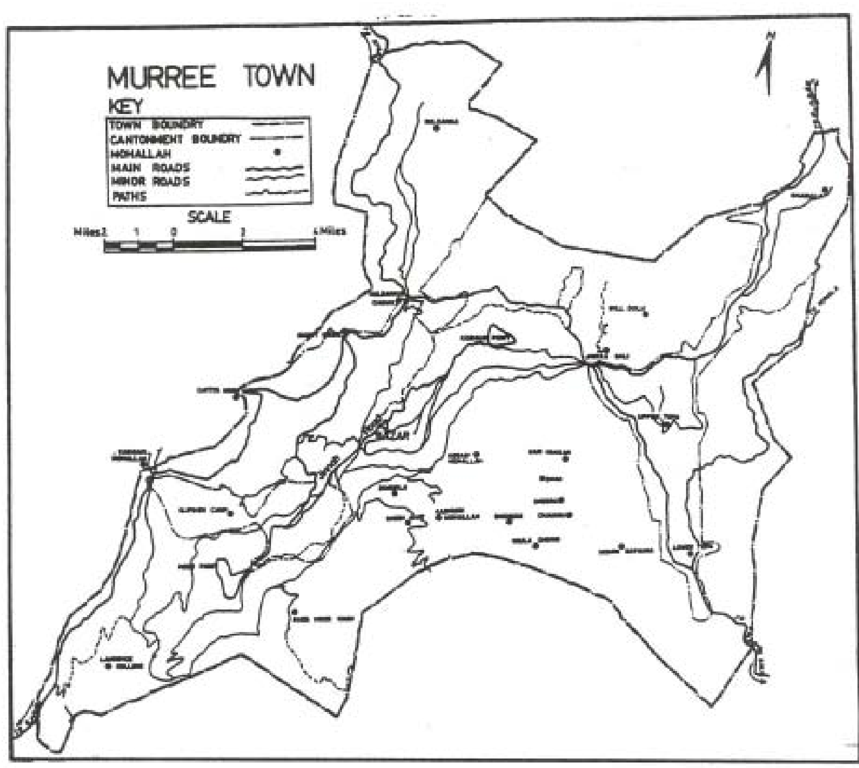

Figure 2

Jabar, Dhak, Bari Nakhar, Bhangan, Choora, Chawana, Mohra Batnara, Maula Dhongi, Ihata Noor Khan, and Murree Brewery (Fig. 2).

Separate "systematic probability samples with random start" were taken from each area by selecting every 10th person from the electoral list. In this way, a total of 245 households among the permanent population of Murree were selected and interviewed. The households were distributed among the three environmental areas as follows: i) Inter city 95; (ii) Urban fringe 48; iii) Rural fringe 102.

These techniques enabled qualitative and quantitative data to be obtained. Data gathered through these techniques wre then coded, processed and analyzed with the SPSSX-3 computer-package available at the Cripps Computing Centre, University of Nottingham, U.K. Statistical analyses were carried out by using descrptive statistics, such as frequencies, percentages, means and contingency tables. The Chi-Square test of independence was used for categorical data, as the hypothesis that two variabels are independent of each other was often of interest in this study. The null hypothesis in all these cases was that the probability of a response/variable in a given column of the contingency table was the same for each cell in the column. A level of significance of 0.05 was generally required to reject the null hypothesis. To measure the strength of relationship between the variables, Cramers's V and Gamma measures of correlation were used, as relevant in some cases (Blalock, 1979; Bailey, 1987).

EXTENT AND CAUSES OF THE LAND-SLIDE HAZARDS IN MURREE

Extent of Landslide Hazards

Throughout the mountainous part of Pakistan, Murree is considered to be the worst slide-affected areas (Pearce, 1987). The landslide hazard in Murree, therefore, has been a cause of great concern for the safety of life and property since the earliest times. However, during the last three decades, the extent and severity of the adverse effects of landslides have increased tremendously. This has seriously endangered people and their property in the area.

As the incidents and damage from landslides have not been reported regularly, and different departments dealing with the landslide problems do not keep separate regular records of their activities, detailed data on the damage and cost incurred through landslide hazards is not available. However, through the limited available records and primary sources, like discussions with the officials and interviews with the households, it is possible to show that landslide hazard in different forms has seriously disrupted man and his activities. Considerable damage has occured to housing, roads, communication lines, electricity and water supply, as well as the retaining structures, in the recent years. Field studies revleaed that more than 70% of houheholds in the area have been directly or indirectly affected by landslide hazards (Khan, 1992a and 1994). It was also found that the households spend a considerable part of their earning on repairing the landslide damage to their house. The yearly cost of landslide damage has been shown to be in millions of Rupees over the last few years. This cost, besides property damage, includes the day to day expenditures designed to curtail landslides.

Poorly regulated development has resulted in increased public expenditures on remedial protections. Also, additional funds have been spent for various public utilities and public services on the slide-proneslopes. The Progress Report of Murree Kahuta Development Authority (MKDA) from 1986 to 89 shows that expenses on landslides have reached Rs. 54,95,000 which is more than 5% of its total budget. This money has been spent on the landslide problems, excluidng afforestation and other related measures adopted by the authority (MKDA, 1989). Likewise, other concerned departments are also spending at the same rate on landslides. Apart from the normal budget, Murree has frequently received huge special grants, over the last 15 years, from provincial government, especially from the Chief Minister and governor of Punjab, for the landslide-problems (Shiwalvi, 1985, 1987b, 1990b). These trends indicate that the landslide-problem accounts for an increasing proportion of the nation's loss from natural hazards in the whole of Murree hills, in general, and in the city of Murree, in partiuclar.

Causes of Increasing Landslide Hazards

The available literature and data, together with the field observations, show that many factors known to cause landslides are present in Murree. These include: young and immature geology, with, highly erodible soils and rocks, steep and irregualr slopes, abundant and seasonally intense monsoon rainfall, active freeze and thaw, evidence of the older landslides, and above all extensive human activities, incluidng deforestation, quarrying, building and road construction (Niederer & Schaffiner, 1988; Niederer, et. al., 1989; Duldulao, 1989; Khan, 1992a, 1994). The data also revealed that the natural causative factors, like geology, topography and climatic conditions, were there since earliest times. Therefore, the problem of landslides has also been persistent; however, not to the extent that it is at present. In the last 20 to 30 years there has been a sharp increase in destruction caused by landslides. The increasing trends in destruction caused by landslides in the recent decades have persisted, in spite of the fact that neither the climate, nor geologic conditions, appear to have changed significantly (Niederer, et. al., 1989). There is no evidence to show that natural factors have contributed to accelerate landslides. The major reason for this increase is the ecological and environmental imbalance caused by man. It has been suggested that it is man's careless and unwise exploitation of land, forests, rocks and other resources that has led to an increase in the losses from landslides (Moughtin, 1986; GOP, 1987). Not only has the population and occupancy of the slide-prone area been expanded, but also Man's ability to change hill-slopes rapidly has produced an anthropogenic landscape (GOP, 1987; Shiwalvi, 1985, 1990a).

In former times, people living in the area were using resources in a traditional and very careful manner, allowing nature and man to co-exist with the slowly transforming processes of change, without frequent and major upheavals (Moughtin, 1986; Niederer, et al. 1989). It has been observed that, at the time when this area was chosen for the development of a hill-station, it was covered by dense forest, dotted with human settlements (Hunter, 1886; Dar, 1986; Rabbani, 1986). Murree is comparatively more readily accessible to, and influenced by, the population-explosion, modern pressures, and urban growth than the remoter high mountain areas. Therefore, over the last few decades, residential development has begun to grow in number and size. Today, residential growth and day to day concentration of social and economic activities continues unabated on the unstable slopes. Besides a growing permanent population, Murree has experienced accelerated pressure from the construction of second homes, tourist accommodation and development of recreation-industry almost round the year. The influx of newcomers from outside the area (from 1947 until today) and from nearby villages (within the Murree Tehsil) to settle here, as well as an increasing number of tourists, has caused a steady expansion in the demand for housing and public services. This demand has been met by new construction and extensive development in the existing town and the surrounding area. As development spread, the ruthless felling of ground-holding trees, masive quarrying, construction of more and more roads and heavy multi-storey buildings, with improper drainage and septic sewerage systems, have disrupted the basic equilibrium of the slopes and have seriously endangered the stability of this beautiful hill-station (President of Pakistan, 1986). Where once the scenery was of evergreen-clad mountains dotted by settlements with light traditional scattered buildings, now it is a juxtaposition of building facades honeycombed with population and intermittently accented by trees. Within the context of increasing density of commercial and urban centres, infrastructure, and increasing propensity for constructing residential housings in the slide-prone areas at such an unabated speed, the severity of the landslide-hazards has increased tremendously. This array of costly and unprecedented problems of landslides have harassed the households and public officials alike. Indeed the drastic effects of man's action, and the severity of the consequences of putting a progressively high premium on a hazardous slide-prone area, can nowhere be better illustrated than in Murree.

POLICY-RESPONSE TO LANDSLIDE HAZARDS

Background of the Policy Response

As the problems of steep slopes and fragile geomorphology have existed in the area since the time when the hill-station of Murree was established in 1849, the government has been trying to tackle the landslide problem in some form since the very begining. Rules and regulations intended to maintain a balance between nature and human activities, were adopted as early as 1851 when "Murree Sanatorium Committee" was constituted (Master-Plan Murree

Town, 1988). In 1867 the Punjab Local Government Act No. XXVI of 1850 was extended to Murree and, consequently, the Muree Sanatorium Committee was converted into "Municipal Committee Murree" (MCM, 1967). Since then it has taken care of the development and planning of the civilian area of Murree city. For the administration of military areas, a separate body called "Cantonment Board Murree" (CBM) was made responsible. The MCM and CBM have subsequently adopted land-use measures and bye-laws, in their respective areas of jurisdiction, to control development in the slide-prone areas and preserve the beauty of the hill-station. The pre-independence population of the town, was very limited. The town was exclusively used by the European population, as well as high military and civilian officials. There were also a number of other hill-stations throughout India (Clarke, 1858); therefore, there was no great pressure on Murree. Hence, the problem of landslides was not so severe.

After independence, the growth, expansion and development of Murree started with increasing human activities. The environment of Murree hill-station and its surroundings became visibly upset. the necessity of creating a balance between nature and human activiites was realized in the early years of independence. Therefore, the provincial government in September 1952 appointed a Murree Hills High-Powered Commission (MHHPC) to look into this matter. The commission was given the responsibility to go into the details from all points of view and suggest methods for reduicng the adverse effects of landslides and other related phenomena. The commission recommended a number of corrective steps, including control on overpopulation. However, the only thing that came out of the commission's work was a request to the Boad of Revenue to provide 620,550 acres of land in the plain areas, to move about 49,665 families. No attempts have yet been made to implement any of its recommendation (MHHPC, 1958; Hunting, 1961).

Despite the failure to implement land-use regulations and recommendations of the High Powered Commission, the escalating landslide problems in the area have successfully attracted the attention of governemnt since the 1970s. Early attempts to control landslides by the government amounted to little more than the retaining walls, particularly on the roadsides. Frequent, severe landslides and increasing development in the area, over the last twenty years, have justified sustained efforts by the government to contain landslides. Therefore, various nation-building departments, such as the Forest, Public Health Engineering, Highway, Building, Soil conservation, Revenue, and Civil administration as well as Municipal Committee Murree, Cantonment Board Murree, Murree Kahuta Development Authority, and Murree Improvement Trust, began to make efforts towards the reduction of the adverse effects of landslides (Niederer, et. al., 1989; Shiwalvi, 1987a, 1990a,b). These governmental agencies have spent, and are still spending, a considerable part of their scarce resources on engineering protective measures to reduce the adverse effects of landslides. However, according to the government's own sources, the problem is being tackled on a day-to-day, rather than on a long-term basis. These organizations have overlapping powers and have no coordination for the allotment of roles and responsibilities among each other, according to their resources and capabilities (Fig. 3).

In 1986 the government had also managed to approach the Swiss government and acquired the services of experts from the Swiss Development Corporation (SDC) for the reduction of landslides. They conducted an extensive survey and submitted their report (Niederer and Schaffner, 1988; Niederer, et. al. 1989). Nevertheless, the prospects are rather bleak, as their report declared the area to be beyond repair due to the multi-dimensional nature of the problem, the socio-economic environment as well as technological and financial constraints of the partner organizations.

Major Policies Adopted for Reduction of Landslide Hazards

To reduce the adverse effects of landslides on housing and services, three major policies have been adopted by the government. They are; i) engineering protection policy, ii) compensation policy, and iii) regulatory policy.

i) Engineering Protection Policy:

The engineering protection policy includes various engineeirng measures to contain landslides and divert the flow of a sliding mass away from housing and other infrastrucutres. This policy is widely adopted by all the governmental agencies and public organizations involved in the landslide problems. It is normally adopted as a curative tool, after the release of landslides. The most dominant measures, so far adopted, are the construction of check dams, retaining walls and buttresses, gabion structures, as well as surface and sub-surface drainage. Almost all these measures are site-specific and are meant to contain landslides, or steer debris flow away from housing, roads, and other property. These measures range from small-scale engineering works to huge structures throughout the study area.

ii) Public Relief or Compensation Policy:

The second option adopted by the authorities is the compensation policy. The compensation is given to those low-income households whose houses have been seriously damaged by landslides and who are not able to replace the damage on their own. It is also given in the cases of injuries and deaths through the landslide incidence. It should also be mentioned here that compensation is very frequently not distributed in each and every case of landslide hazard. It is given mainly in those cases where a large number of people and properties are involved in the incident.

The MCM and other organizations normally invovled in the problem have not enough funds to deal with this policy. The main source for compensation, therefore, is special grants from the provincial government and, in some special cases, even from federal authoriites. There are emergency relief cells at the federal and provincial level. At a lower level, the relief commissioner is normally the district administrator who, in the case of Murree, is the Deputy Commissioner Rawalpindi. The Relief Commissioner, according to the National Calamities Prevention and Relief Act 33 of 1958, is responsible for the coordination of all the relief activities (GOP, 1958). The concerned households normally have to make a claim for landslide-damage to their relief commissioner, with local revenue administration acting as an agent, passing the claims on. The applicants are required to provide proof that the damage to their household was caused by landslide.

The testification by the area's National or Provincial Assembly member, or at least an influential Municipal Member, is usually considered as proof in such cases.

iii) Land Use and Regulatory Policy:

In Murree, various regulatory measures have been adopted to control development, and reduce the adverse effects of landslides. These measures range from the preservation of slopes, through the maintenance of dense vegetative cover and a total ban on quarrying, to land-use and building bye-laws (MCB, 1929). It was discovered that some bye-laws and regulations to control development of the town were already in existence in the early 1850's (MCM, 1967). At present, there are two sets of bye-laws operated by MCM and CBM in their respective areas of jurisdication. The major purpose of these bye-laws is to prohibit unplanned development and statically indeterminate structures, such as multi-storey heavy-weight concrete buildings, which place a huge pressure on the land that the fragile topography of Murree simply cannot afford. The underlying idea in adopting this approach was to curb the increasing trends of construction caused by inflation of population, and discourage the urge to build prestigious houses that put a high premium on this slide-prone area.

EFFECTIVENESS OF THE POLICY-RESPONSE

This section will look at the performance of the policies adopted for the reduction of the adverse effects of landslides. The major yardstick used here, to gauge the performance and effectiveness of the policies, is their ability to reduce the adverse effects of landslide on housing and other infrastructure.

Engineering Protection-Policy and Reduction of Slide-Hazard

Among the three major policies adopted by the government, the engineering protection-policy was found to be the most frequently used for the reduction of adverse effects of landslides. These measures can be easily observed, at first glance, in Murree and surrounding areas, as one enters this region. The engineering protections are politically visible and easy to adopt, and are, therefore, preferred by the public representatives as well as government organizations. An overwhelming majority of households (71.8%)

Table 1: Types of Policies adopted by the LHRP

Responses	Frequency	
	Number	%
Engienering Protection Policy	253	73.3
Compensation Policy	79	22.9
Regualtory Policy	13	3.8
Total	345	100.0

Source: Field Survey, 1990

Table 2: Engouragement with Engineering Protective Measures as a Reason for Settling Down in Murree by Migration Pattern

Reason for Settling Down in Murree	Migration Pattern				Total	
	Migrated		Local			
	No.	%	No.	%	No.	%
Encouraged by the scale of engi-neering measures	93	66.9	12	11.3	105	42.9
Other reasons for settling	46	33.1	94	88.7	140	57.1
Total	139	100.0	106	100.0	245	100.0

Chi-Square=6.267
Significance=0.0123
D.F.=1
Cells with E.F. < 5=None

Phi Coefficient=0.168
Significance=0.0041

Source: Field Survey, 1990

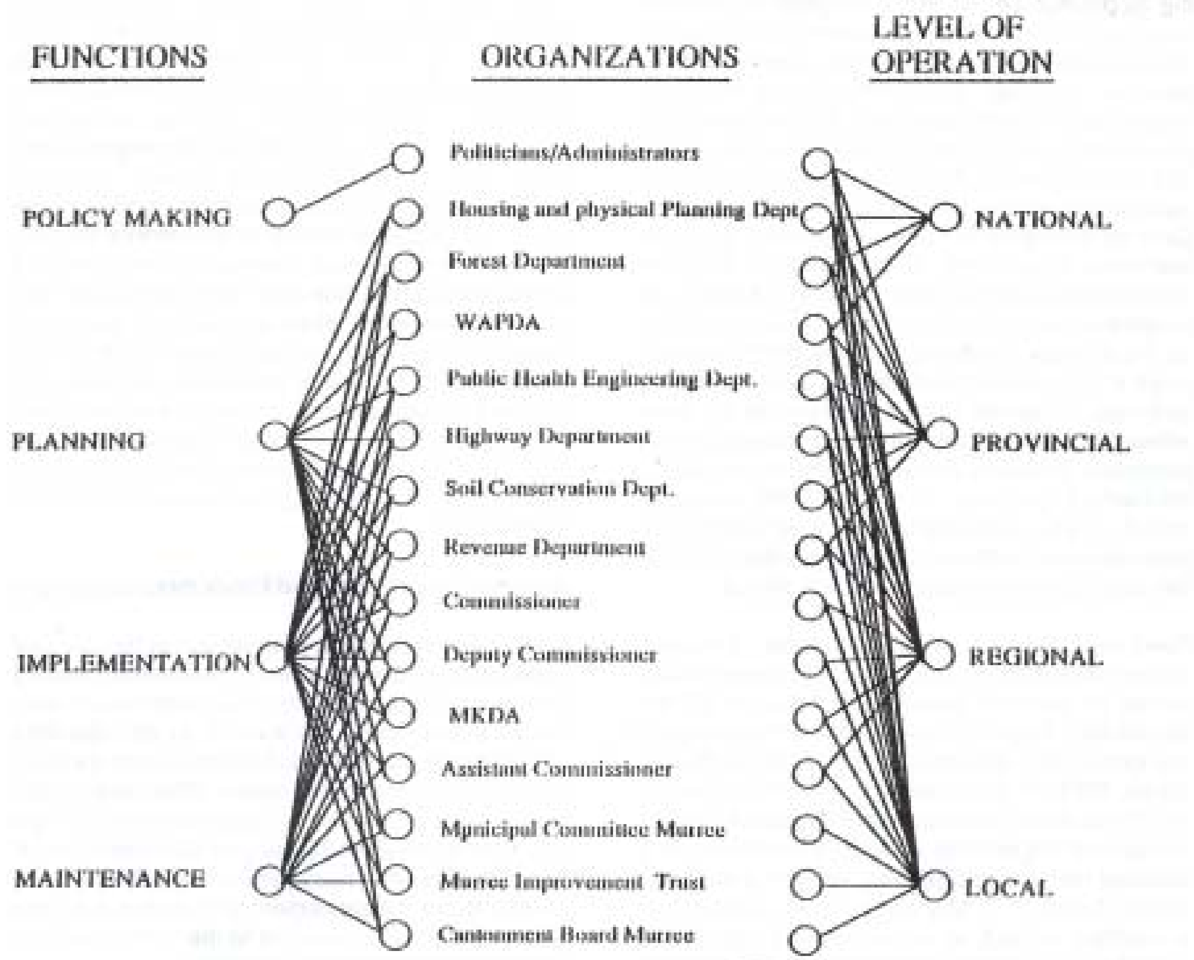

Fig.3 Existing Organization, Their Functions and level of Operation in Murree.
Note the Overlapping of the Organizations in Development Planning Function in the Town.

were found to be appreciative of the government efforts in this regard. While explaining the type of policies adopted by the government, these 71.8% (176) households in their multiple-response answers (upto two) gave a total fo 345 responses. Among these, the dominant majority (73.3%) were about the various engineering protective measures like construction of retaining walls, gabion structures, check dams, surface and subsurface drainage, etc; 22.9% of responses were about compensation; and only 3.8% were related to bye-laws and regulatory measures (Table 1).

The high level of response about the engineering protections, therefore, appears to be an indication of the over-emphasis of the authorities on curative measures. This increasing reliance on the curative measures by the authorities began over the last two decades, especially since 1980, as lots of special grants were made available by the provincial government during this period (Shiwalvi, 1985, 1987b). However, during the same period, the adverse effects of landslides have rapidly escalated. Data on the extent of landslide hazards, analysed elsewhere (Khan, 1994), disclosed that 70.3% of the suffering households were adversely affected by landslides in only the last ten years (1980 to 1990); 23.1% have been affected since the 1970s; whereas only 6.6% households were affected more than twenty years ago, i.e. before 1970. As many as 94.5% of the affected households also confirmed that engineering protective measures are not a complete answer to the landslide problem. They were of the view that, though public expenditures on slide control and protection work proliferated, yet the landslide damage has continued to escalate during this period.

Field studies have revealed that the increasing reliance on engineering measures has created a false sense of security among the majority of the households. This factor was found to have played a big part in their decision to settle down in Murree (Khan, 1994). It was found that a two-third majority (66.9%) of those households who migrated to Murree considered engineering protective measures as a deciding factor in encouraging them to settle down there (Table 2). They hoped that engineering protections on such an unprecedented scale would be sufficient to keep the landslide hazards away from them. Analysis with the Chi-Square test of independence revealed a significant association between a household's encouragement by engineering protective measures as a reason for settling down in Murree and the migration pattern. The test also indicates that engineering protections, when given as a reason for encouragement to settle down in Murree, have a positive correlation of 0.20 (Phi=0.16836) with the migration pattern.

This evidence, therefore, indicates that, there is a need to bring about changes in basic policy-approach to reduce the adverse effects of landslides in the area. The strong association between engineering protections as a reason for settling down in Murree and the migration-pattern may provide a key to potential-policy changes. The authorities probably need to adopt a comprehensive approach, which could suitably combine slide-control curative methods with appropriate long-term measures. These measures include land-use planning, zoning and subdivision, regulations for hill-slide development and some special developmental policies. It seems necessary, because policies for reducing the adverse effects of landslides aim not only to reduce the risk, but at the same time, to control man-induced aggravation of landslide risk. These two benefits can often be achieved when engineering protective measures are used *in conjunction with* strictly implemented regulatory measures and land-use planning. Needless to say, such a combination is also more likely to reduce the burden on public-resources, and enhance the active participation of the local population in future slide-hazards reduction programmes.

Compensation Policy and Entitlement Conditions

It has been a common observation in the relevant literature that, although all the households are equally prone to landslide hazards, those with low-income, insecure jobs, and a low level of, or no, education are highly vulnerable and suffer serious slide-damage. Therefore, there is a need to look at the impact of the compensation-policy of the government to see how far it is helpful for the low-income households. It will try to identify how many people can fulfil the basic conditions for the entitlement of compensation, and who they are, with reference to the socio-economic profile of the households in the area.

In the compensation policy, there are various conditions to be fulfilled by the applicants in order to qualify for compensation. Apart from the proof of ownership of the property concerned, the basic condition for the entitlement of compensation is the testification by the area's National/Provincial Assembly members that damage to the house of the applicant was really caused by landslide. It was, however, found that a dominant majority of the households are not able to fulfil this condition, as they have no way of approaching any testifying authority. The analysis revealed that, among the 182 affected households, more than three-quarters applied for compensation; among them a dominant majority (71.9%) was found to be unsuccessful in getting compensation. It was found that out of these 71.9% (one hundred) households, three-quarters (72%) had no way of approachig any testifying authority.

Thus it was necessary to see whether or not the lack of approach of households to testifying authorities has any relationship with their socio-economic status. The reasons for not being able to receive compensation were examined with the important socio-economic factors, like educational level and occupation of the households heads, and income-level of the households (Table 3). It was found that the percentage of those who were not successful in getting compensation,because of having no way of approaching any testifyng authority to present proof of slide damage along with their applications, was 40% among the illiterate and 35.1% among less-educated (Primary/Middle) households heads. These percentages were quite high as compared to 15.9% and 12% of the household heads with Inter/Matric and Degree-level education, respectively. Similarly, 53.7% people in the informal sector, and 41.5% in the low-salaried formal sector, were not able to fulfil the basic condition for the entitlement of compensation, whereas this figure was only 17% for businessmen. It was also found that those who have no access to compensation, because of not having approach to any public representative, were mainly among the lower-income (63.2%) and lower-middle income (25.8%) groups. On the contrary, no one among the upper and upper-middle income groups was found to have any problem with providing proof of slide-damage to get compensation.

The Chi-Square test revealed a significant association between the lack of approach to testifying before authorities and socio-economic indicators of the house-holds, including educational attainment, occupation and level of income, at significance levels of less than 1%. A significant correlation between the two variables was also noticed (Table 4).

The study also considers it necessary to examine the extent to which the important socio-economic factors are related to success in getting compensation. It was found that more than two-thirds (66.7%) of those having degree-level education and 75% of the upper-income group were successful in getting compensation, whereas among those with no formal education only one quarter (25%) and 7% of the lower-income group were in the successful category. It was also found that virtually all the households having access to compensation had secure jobs, with the majority (28 out of 39) in profitable business (Table 5).

Hence, to summarize, the study unfolds that those who have access to compensation belong to high socio-economic groups, with a higher educational attainment, better occupation and upper income level. On the contrary, households with lower socio-economic status, who are particularly affected and vulnerable,have no access to it.

Regualtory Policies and Implementation

During the field study, it was found that the authorities have not been successful in implementing these regulatory measures, due to the absence of a proper institutional framework and organizational set-up. The lack of implementation of these regualtory measures is obvious from the response of 176 househods, who expressed awareness about government policies on landslide hazard-reduction. As shown earlier (Table 1), only 7.4% respondents, who appreciated government policies, were aware of the regulatory policies. This, however, does not mean that housheolds have a low level of awareness about regulatory measures, because their full awareness about these measures is indicated by many of their responses during the interviews. However, as these regulatory measures have not been implemented and also not emphasized as much by the authorites as the engineering control, the majority of the respondents avoided this in their responses.

Table 3

HAVING NO APPROACH TO ANY TESTIFYNG AUTHORITY AS A REASON FOR NO ACCESS TO COMPENSATION, BY SOCIO-ECONOMIC FACTORS

(A) Education Level

Reason for no access to compensation	Household Heads Education Level*									
	I		II		III		IV		Total	
	No.	%	No.	%	No.	%	No.	%	No.	%
No Approach	32	40.0	27	35.1	10	15.9	3	12	72	29.4
Other Reasons	48	60.0	50	64.9	53	84.1	22	88	173	70.6
Total	80	100	77	100	63	100	25	100	245	100

*I = Illiterate, II = Primary/Middle, III = Matric/Inter, and IV = Degree Level

(B) Major Occupation

Reason for no access to compensation	Occupation of the Household Heads**									
	I		II		III		IV		Total	
	No.	%	No.	%	No.	%	No.	%	No.	%
No Approach	29	53.7	17	41.5	3	20.0	23	17	72	29.4
Other Reasons	25	46.3	24	58.5	12	80.0	112	83	173	70.6
Total	54	100	41	100	15	100	135	100	245	100

**I = Informal Sector incluidng farming and casual labourer
II = Formal Sector including teaching, clerical jobs, and non-clerical services
III = Retired Servants, IV = Businessmen includng contractors, hoteliers, and small and large scale retail or wholesale traders.

(C) Income Level

Reason for no access to compensation	Households, Income Level***									
	I		II		III		IV		Total	
	No.	%	No.	%	No.	%	No.	%	No.	%
No Approach	48	63.2	24	25.8	--	--	--	--	72	29.4
Other Reasons	28	36.8	69	74.2	65	100.0	11	100	173	70.6
Total	76	100	93	100	65	100	11	100	245	100

***I = Lower Income Group, II = Lower-Middle Income Group, III = Upper-Middle Income Group, and IV = Upper Income Group

Table 4

Summary of Relationship of Lack of Approach to any testifying authority as a reason for no access to relief with socio-economic indicators

Households Socio-Economic Characteristics	Chi-Square	D.F.	Significance	Correlation Coefficients*
Education Level	14.726	3	0.0021	0.245
Major Occupation	28.828	3	0.0000	0.343
Income Level	73.972	3	0.0000	0.549

* Cramer's V Correlation Coefficient was used in all these cases. all these correlation coefficient were significant at less than one percent level (Significant = 0.0001).

Source: Field Survey 1990

Table 5

ACCESSIBILITY TO COMPENSATION BY SOCEIO-ECONOMIC FACOTRS

(A) Education Level

Accessibility to Compensation	Household Head's Education Level*									
	I		II		III		IV		Total	
	No.	%	No.	%	No.	%	No.	%	No.	%
Access	13	25.0	9	20.0	9	30.0	8	66.7	39	28.1
No Access	39	75.0	36	80.0	21	70.0	4	33.3	100	71.9
Total	52	100	45	100	30	100	12	100	139	100

*I = Illiterate, II = Primary/Middle, III = Matric/Inter, and IV = Degree Level

(B) Major Occupation

Accessibility to Compensation	Household Head's Occupation**									
	I		II		III		IV		Total	
	No.	%	No.	%	No.	%	No.	%	No.	%
Access	6	15.4	4	15.4	1	20.0	28	40.6	39	28.1
No Access	33	84.6	22	84.6	4	80.0	41	59.4	100	71.9
Total	39	100	26	100	5	100	69	100	139	100

**I = Informal Sector incluidng farming and casual labourer

II = Formal Sector including teaching, clerical jobs, and non-clerical services

III = Retired Servants, IV = Businessmen includng contractors, hoteliers, and small and large scale retail or wholesale traders.

(C) Income Level

Accessibility to Compensation	Households Income Level***									
	I		II		III		IV		Total	
	No.	%	No.	%	No.	%	No.	%	No.	%
Access	4	7.0	19	35.8	13	52.0	3	75.0	39	28.1
No Access	53	93.0	34	64.2	12	48.0	1	25.0	100	71.9
Total	57	100	53	100	25	100	4	100	139	100

***I = Lower Income Group, II = Lower-Middle Income Group, III = Upper-Middle Income Group, and IV = Upper Income Group

The lack of implementation of these regulatory measures, according to the households, has been considered as one of the main reasons for the increasing frequency and size of landslides in the area. The respondents emphasized that bye-laws regarding construction had not been abided by during the last few decades. Lack of implementation of regulatory measures concerning faulty construction, and drainage and sewerage system, conservation of steep slopes (including deforestation and quarrying), growth of the city, rapid urbanization, and the natural causative factor of climatic changes were some other major factors, according to the respondents.

It was pointed out by the households as well as the officials that the organizational weakness is perhaps the single most important factor responsible for the lack of implementaion of bye-laws and regulatory measures. There is no organization with sole responsibility to implement the regulatory measures. To control and regulate new development a Building-Plan Committee has been constituted. It is working under the chairmanship of Deputy Commissioner Rawalpindi with the heads of various nation-building departments as its members. Discussion with members of the committee revealed that there are difficulties in holding regualr meetings because of the multi-departmental nature of the committee. The members also observed that the committee has seldom approved building plans as most of them were not in accord with the bye-laws. All the plans, for instance, involving more than two storeys in a building are rejected outright. The basic idea, they said, is to discourage the increasing construction activities because such activities accelerate the process of landslides, and lead to the accumulation of a progressively high premium on the slide-prone locations. That is why, in the five years between 1984 and 1988, among the total of 870 applications, only three building plans were apporved by the committee, while in 1989-90 the committee received a total of 360 applications, out of which sixty were approved, owing to severe political pressures. However again, according to the committee's sources, all the unapproved buildings have also been erected, in clear-cut violation of the bye-laws. Most of the unauthorised structures are commercial buildings, particulary hotels, which belong to the local and external political elite and influential wealthy notables. In a situation like this, the function of the building-plan committee has been paralysed.

Field survey revealed that these developments have created a slipshod perception and a degree of uneasiness about the curbs, within the building regulations and the slide hazard-reduction programme, among the common citizens. As many as 90% of the households complained about the infractions discrimination and lack of implementation capabilities of the existing institutional framework. They thought that it was the exisitng organizational set-up, and the ineffective way it uses the curbs in the building regualtions, which were responsible for all the unauthorized construction, mushroom growth, and encroachments that have cropped up during the last few decades, without any regard to the regulations and the natural environment. According to these households, all the irregulations were going on with the connivance of the authorities concerned, as they have forced the people to clandestinely construct their apartments illegally by greasing the palms of the officials. Though they do not object to the need for regulatory measures to reduce the losses, they are of the view that the curbs, through such a multi-departmental body, are being used to open new avenues of corruption and discrimination.

The survey further revealed that there is no follow up, coordination and consultation at any level, neither between the authorities and the local people, nor even among the authorities of different organizations involved in the programme. The authorities have not been able to probe into the unauthorized construction, and unearth the hands responsible for the malpractice. It can, therefore, be concluded that the present organizational set-up has probably aggravated the problem of landslides. Hence, to effectively reduce the adverse effects of landslides, it is necessary to have a single cohesive and powerful organization with sole responsibility for tackling the policies of the landslide hazard reduction programme.

SUMMARY AND CONCLUSION

This study found that the dominant policy adopted by the authoriites was based on engineering protective measures. An overwhelming majority (71.8%) of households were found to be appreciative of the efforts of government in this connection. It was established that the over-emphasis on the engineering protective measrues began in the last two decades, i.e. since 1970. However, during this period, the adverse effects of landslides on housing and other properties were also found to have escalated. The study has, therefore confirmed that the strategy of relying solely on engineering protection has not been able to reduce the adverse effects of landslides in the area. On the contrary, it was found that this strategy has proved to be self-defeating, as it has created a false sense of security among a majority of the households, which played an important part in their decision to settle down in Murree. Majority of those households who migrated to Murree over the last few decades were impressed and encouraged by the scale of the engineering protections adopted by the authorities. Therefore, they settled in Murree with a hope that these measures on such a large scale would be sufficient enough to keep the slide-damage away from them. It can be concluded that engienering measures on their own, being not really effective in solving the problem, should not, therefore, be applied as a single and dominant policy-instrument. It is more likely to reduce the adverse effects when used in conjunction with the strictly implemented land-use and regulatory measures.

The analysis also revealed that, although the compensation policy was meant to compensate slide-related damage of the low-income households, it had largely failed in this regard. In contrast, it has assisted those how have a higher socio-economic status, with higher educational attainment, a secure and better job, and an upper income level. This situation was found to be the product of the basic requirement and conditions set down for the entitlemnet to compensation. The analysis further revealed that inaccessibility to the testifying authority, when given as a reason for not receiving compensation, had a significant relationship to the important socio-economic factors. It can, therefore, be concluded that the conditions of providing proof of slide-damage has been practised in a manner that has excluded the majority of the households with lower socio-economic status from the benefit of compensation.

As far as regulatory policy and its implementation is concerned, it was observed that various regulatory measures have been adopted from the very beginning to control development, and thus, reduce adverse effects of landslides. It was, however, found that there was no organization solely responsible for implementing these regulations. Other non-specific authorities lack implementation-capability, and were found totally unable to control infractions, successfully. It has been pointed out that, as a result of the lack of implementation capabilities, activities like faulty construction, deforestation, and quarrying were going on without any regard for regulations and the natural environment. These infractions were found to accelerate the speed and extent of the adverse effects of landslides.

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BIO-SCIENCES AND AGRICULTURE

BREEDING FOOD AND FORAGE LEGUMES FOR ENHANCEMENT OF NITROGEN FIXATION: A REVIEW

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ABSTRACT

Nitrogen fixation in legume - root nodules requires the functioning of genes present in the rhizobia that induce nodule-formation. The plant produces the nodules and the energy required for respiration. Genes in both Rhizobium and the plant are responsible for the efficient use of photosynthates for N_2-fixation and assimilation of nitrogen. Genes from Rhizobium and legume hosts that are involved in the symbiosis are being identified, isolated and cloned, to facilitate the manipualtion of either partner. The amounts of nitrogen fixed by grain-legumes vary appreciably, between and within, species, and are also influenced by environment. With few exceptions, most legumes fix insufficient N_2 to support substantial seed-yields. Deficits between the required N and the combined amounts provided by soil and fertilizer help in estimating the improvements in N_2-fixation which is possible through breeding. Since the symbiosis is a complex process, heritability of traits is weak, and most methods which estimate fixation are destructive; a breeding method that allows selection of replicated families rather than single plants is preferred.

INTRODUCTION

Biological nitrogen (N_2)-fixation is estimated to be 65% of the nitrogen (N) currently utilized in agriculture, and is expected to become increasingly important in future crop-productivity, particularly for sustainable systems (Thomas et al., 1997). It involves the enzymic reduction of N_2 gas to ammonia; this reaction is catalyzed only by certain prokaryotic micro-organisms using the enzyme nitrogenase. Nitrogen-fixing micro-organisms are found in most habitats; the most significant ones, in terms of the amount of N_2 fixed per annum for agricultural purposes, are those found on plant roots. By far the most important bacteria involved in nodule formation are species of *Rhizobium* and *Bradyrhizobium* which nodulate different species of leguminous plants. Amounts of N_2 fixed per annum vary with crop, soil- type and husbandry, and are usually in the range of 30-300 kg per ha per annum (Beringer et al., 1988).

The cereal crops always yielded higher when used in rotation with legumes (Doyle et al., 1988; Marcellos, 1984). The wheat crop, when planted after chickpea, gave the yield increase from 0.5 to 2.1 t ha-1 over the crop followed by wheat in Australia (Marcellos et al., 1993). Economic analyses revealed that crop- rotation of over four years, involving chickpea and wheat without any nitrogen fertilizer) gave an increase up to 162% in income, from sequences involving chickpea when compared with continuous wheat (Marcellos et al., 1997). The intercropping of pigeonpea with sorghum increased the yield of sorghum tremendously and the biological nitrogen-fixation enhanced the nitrogen status of the soil, resulting in reducing the use of nitrogenous fertilizer in sorghum crop (Addu-Gyamfi and Ito, 1997).

Symbiosis of legumes and rhizobia results in nodule- formation on host roots. Nodule formation begins with bacteria-plant interaction in the rhizosphere and involves the induction of specific genes in both symbionts (Murphy and Thompson, 1988; Long, 1989). The induction of rhizobial nodulation genes (nod) by host-specific flavonoids, which serve as the signal molecules in specific host legumes, is a very critical stage (Hopper et al., 1995). A number of plant-genes are involved in the process of Rhizobium- associated N_2 fixation. Some of the genes induced during the early stage of infection include Rhizobium-induced peroxidase (rip1) (Cook et al., 1995), and ENOD5 and ENOD12 (Scheres et al., 1990). During nodule-development, there are complex interactions between the host-plant and the rhizobia infecting

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the plant. To understand these interactions, both plant and rhizobial mutants are necessary for studying various stages of nodule formation and function (Miller et al., 1991).

Specific genotype-strain combinations that result in enhanced nodulation, increased N_2 fixation and increased yields have been identified (Caldwell and Vest, 1968; Kvien et al., 1981). The success of these enhanced genotype-strain combinations, in a heterogeneous soil environment, will depend on the survival and competitive ability of the inoculant *Bradyrhizobium japonicum* strain and on the ability of host-plant to preferentially nodulate with the inoculant strain (Greder et al., 1986). Selection of lines having decreased ability of nodulation with native strains, but possessing the ability to recover introduced inoculum-strains at high levels, may be a means by which superior genotype-strain combinations can be successfully utilized in the field (Devine and Weber, 1977). Improved *rhizobia* have been produced by genetic manipulation, but field-performance of improved strains has been disappointing and attributed to lack of competitive ability against native populations (Noel and Brill, 1980). Despite the ability of legumes to fix atmospheric nitrogen, the N_2 derived from fixation alone is seldom sufficient to produce large seed-yields. Plants must rely on additional sources to meet their N-requirements (Harper, 1974; LaRue and Patterson, 1981). The essential role of the host-plant in maximizing symbiotic performance is often overlooked and that role is also poorly understood (Bliss and Miller, 1988).

In cereal (non-legume) crops, bacterial genera *Azospirillum, Azotobacter, Acetobacter, Alicaligens, Bacillus, Enterobacter, Herbaspirillum, Klebsiella and Pseudomonas* have been found as their colonizers (Baldani et al., 1986; Roger and Watanabe, 1986; Cavalcante and Dobereiner, 1988; Berge et al., 1991; You et al. 1991 Malik et al., 1994; Mehnaz et al., 1998). Their beneficial effects have been related to biological nitrogen-fixation and production of pyhtohormones that promote root-development and proliferation for efficient uptake of water and nutrients (Tien et al., 1979; Hartmann et. al., 1983. Haahtela et al., 1990). The use and application of bacterial inoculants as biofertilizers has resulted in improved growth and increased yield of cereal crops (Kapulnik et al., 1981; Boddey et al., 1986; Pereira et al., 1988, Kennedy and Tchan, 1992). The DNA-based and immunological studies are underway on the root-colonization and survival of bacteria in the rhizosphere (Vermeiren et. al., 1996; Mehnaz et al., 1998). The effect of *Azospirillum* inoculation, under different levels of farmyard manure, on N_2 fixation, growth and N-yield of two maize cultivars was studied by Elkomy et al. (1998). They found that *Azospirillum spp*. showed a higher degree of host specificity. Like *Rhizobium* strain selection in legumes, they suggested that numerous strains must be isolated from different origins, characterized, and tested under various environmental conditions of each plant cultivar. Furthermore, (Pishchik et al. (1988) found a significant positive effect on yield of potato cultivars, afer inoculating with *Klebsiella mobilis* strains, increasing the yield 1.2-1.4 times as compared to non-inoculated plants.

Improved capacity for fixing N_2 is an environmentally and socially important development, with potential for reducing N-fertilizer requiremnts for crop-production (Hardy, 1985).

The objectives should be to increase the total amount of plant N_2-fixation, the proportion (%) of N derived from fixation, and the yield resulting from fixed N_2.

STRATEGIES FOR PLANT IMPROVEMENT

Effective improvements through breeding for increased N_2-fixation depend on the amount of genetic variability in the gene pool, relations among plant-traits that either enhance or limit fixation, use of an appropriate method for estimating N_2 fixation, the effectiveness of the breeding method used, and favourable host-plant interactions with strains of *Rhizobium*. The number of bacteria and their nitrogen-fixing efficiency were estimated, using improved and local cultivars in the highlands of Turkey. Native rhizobia, specific to the local landrace, were more abundant than those specific to the improved cultivar, but nitrogen-efficiencies of all isolates were consistently poor. The identification of symbiotically efficient and econologically persistent strains of *rhizobia* were

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suggested in order to improve nitrogen-efficienices (Keatinge et al., 1995). Maximum selection-response for increased fixation is not likely to be realized in situations where external N is in abudnant supply. However, the breeding objectives may include developing plans capable of fixing N_2, in the presence of abundant N. It may also be desirable to select plant-genotypes that will, in addition to fixing N_2 effectively on poor soils, respond to added fertilizer N. Field plot designs and management and breeding methods used can be modified to accommodate these objectives (Bliss and Miller, 1988).

As symbiotic plant-response is dependent on both the host-plant genotype and the microsymbiont, plant-improvement strategies should therefore consider the rhizobial population to be encountered during commercial production. Devine and Weber (1977) suggested selection of soybean genotypes resistant to indigenous rhizobia, and susceptible only to a specific strain, to be added as inoculant. A contrasting strategy is to select a host genotype, such as many Asian and African soybean cultivars that are modulated excessively by native rhizobia (Nangju, 1980).

(i) Genetic Variability in Host Plant

Indirect estimation methods have been used to identify cultivar variability for N_2-fixation potential in various leguminous crop species. It varies from species to species and vice versa.

Differences in acetylene-reduction activity (ARA) values among breeding-lines were shown to be heritable in common bean (McFerson, 1983), cowpea (Miller et al., 1986), groundnut (Arrendell et al., 1985) and mungbean (Fernandez and Miller, 1985a). Similarly, nodule-mass values and number of nodules per plant were heritable and positively correlated with ARA. It suggests that these traits may be used as criteria for selection in the improvement-programmes.

Ronis et al. (1985) reported that, in two soybean populations, broad-sense heritability estimates ranged from 0.59 to 0.6 0 for fixed N_2 content of the seed, and from 0.12 to 0.43 for percentage total seed N from fixation. In common bean, although heritability of fixed N_2 was not determined, Attewell and Bliss (1985) found that inbred backcross lines of black bean and white navy bean, selected for increased N_2-fixation by indirect methods, fixed more total N_2 and had derived a larger percentage of total N from fixation. Seed-yields were equal to, or greater than, the standard cultivars.

Some studies of host-plant traits that influence fixation have been made. Path-coefficient analyses of variables associated with fixation in cowpea have indicated that nodule-weight per plant was the main parameter contributking to N_2-fixation activity, while nodule number per plant was important, mainly through correlation with nodule weight (Miller et al., 1982). Yield-component analysis in cowpea (Fernandez and Miller, 1985b) has indicated that nitrogen nutirtion, whether from fertilizer or N_2 fixation, strongly influenced pod-number per plant, and that this component was a reliable indicator of N_2-fixation ability. However, other components (e.g. seed number per pod and mean seed weight) were fairly stable and cultivar-specific and, so, were unaffected by inoculation or N fertilization. They suggested that breeding-efforts to enhance N_2 fixation potential should focus on increasing the pod-production and retention.

When environmental stresses are experienced by legumes, additional plant characteristics may become important. In cowpea, the effect of water-stress on N_2-fixation variables was far greater than the influence of genotype, when those genotypes were selected for relative drought-resistance (Walker and Miller, 1986). Path-coefficient analysis revealed that leaf-water potential was correlated positively with N_2 fixation in water-stressed plants, indicating that maintenance of leaf-water potential should increase N_2-fixation potential during periods of water-stress. In this situation, breeding for drought -resistance and N_2-fixation may be more beneficial than selecting only for N_2-fixation potential, without regard to environmental adaptation.

Sinclair et al. (1991), using stability analyses in soybean, showed that those lines with the greatest mean nodule-weight also had the greatest positive response to favourable environments. Nodule weight and their number were highly correlated traits (r>0.84). Root and shoot-weight had moderately positive correlatiions with nodule-number and nodule-weight. Heritability studies on nodulation indicate a potential for breeding to improve nodulation in soybean (Ronis et al., 1981; Wright, 1982; Greder et al., 1986). Seed yield in the study of Greder et al. (1986) was found to increase with an increase in the nodule-weight. Wright (1982) assessed the broad sense F_2-heritability estimates for nodule number, size and mass of 27 soybean genotypes. His estimates indicated that a substantial portion of the F_2 variance was due to genetic segregation. The distributions of F_1 and F_2 populations indicate the involvement of few genes that control host nodulation. In a recent study, Miller et al. (1991) have reported inheritance of non-nodulation in 10 sweetclover mutants, determined from F_1, F_2, and F_3 generations derived from crosses between each mutant and the nodulating accession. It was concluded that non-nodulation in each mutant was conditioned by a single recessive gene. The complementation analysis on F_1 and F_2 seedlings , derived from diallel crosses among the mutants, was also performed. It was found that five of the mutants were nonallelic, indicating that at least five different genes are involved in nodule-formation in sweetclover. In chickpea, a single recessive gene was found to control non-nodulation in all, except two mutants where no particular genetic pattern was observed (Singh and Rupela, 1997).

(ii) Estimatiion Methods for N_2 Fixation

The most widely-used methods of estimating N_2-fixation in legume crops include: 1) nitrogen accumulation; 2) difference methods; 3) isotope methods; and 4) techniques that assess variables associated with fixation (LaRue and Patterson, 1981; Weaver and Miller, 1986).

Estimation of total plant-N by standard procedures (such as Kjeldahl determination) is simple and inexpensive. Although these estimates may not reflect the precise amount of N_2 -fixation (since the N source cannot be determined accurately) they may provide reliable estimates for comparisons *between* lines. Even on poor-fertility soils, or when soil has been impoverished artificially, plants can scavenge the soil for N_2 and so estimates of N_2-fixation based on total plant-N may be optimistic (LaRue-and Patterson, 1981).

The procedures used to account for the contribution of soil-N are known as difference methods. Alternative versions may employ comparisons of: 1) the test legume to a non-legume; 2) the test legume to a non-nodulating legume (as some of the non-nodulating mutants in sweetclover); 3) inoculated and uninoculated legumes; or 4) fertilizer equivalence (LaRue and Patterson, 1981). Comparisons of fixing legumes with a non-nodulating isoline of that crop are desirable, but isolines are limited to only a few standard cultivars of some legumes. Non-nodulating mutants have been described in different leguminous crops. A recent finding is reported in sweetclover (Miller et,al., 1991) and chickpea (Singh and Rupela, 1997). The non-nodulating variants can be appropriate non-fixing reference crops for quantification of N_2 fixed by nodulated chickpea by ^{15}N-based and difference methods (Rupela, 1997).

The difference method, which compares the N in un-inoculated and inoculated legumes, is feasible when there are no compatible native rhizobia. The sites having compatible native rhizobia in abundance may be used for idenitfyng plant-genotype capable of being nodulated, selectively, by a superior strain in competition with wild rhizobia.

The N accumulated by the nodulated legume may be compared to that in similar legume-plants by giving different amounts of fertilizer N. The comparisons of plant-yields, from addition of fertilizer N with those of plants fixing N_2, may help to identify plant-genotypes capable not only of fixing N_2 in the absence (or presence) of combined N, but also responding to different amounts of added N.

N_2 fixation can be estimated by ^{15}N-isotope dilution, where the fixing legume and a non-fixing control are grown on soil to which ^{15}N has been added as labelled nitrate or ammonium (McAuliffe et al., 1958). With this method, there are certain disadvantages like non-uniformity of enrichment in the soil and the ability to obtain only semi-quantitative data. A thorough review of procedures and potential sources of error should precede use of isotope methods (Hauck and Bremner, 1976).

Fixation and fixation-potential have been estimated indirectly from variables associated with fixation. The acetylene-reduction assay (ARA), based on the fact that nitrogenase reduces acetylene to ethylene, has been widely used. Many versions of the method exist (Hardy et al., 1973); the most common involves incubation of freshly-excised nodulated roots in a vessel with 1-20% C_2H_2 for 30-120 min, after which a sample of the gas- phase is removed and the ethylene produced measured by a gas chromatograph (LaRue and Patterson, 1981). Conventional use of ARA involves destruction of the plant, making repeated observations impossible. The ARA method has been used in breeding studies to obtain estimates of differences among genotypes for fixation-potential (McFerson, 1983). These estimates were most useful when replicated samples were collected together with data such as plant biomass and seed-yield for the same experimental lines.

Other indirect methods, like nodule number and mass per plant, leghaemoglobin concentration in nodules, visual nodulation scores, and ureide concentration in the xylem sap or in various plant parts (Rosas and Bliss, 1986), have been used to estimate fixation -potential. These methods provide indicators of nodulation and active fixation, and can thus be used with appropriate caution to provide rankings among genotypes being evaluated for selection.

(iii) Molecular Approach

In recent years, considerable attention has been given to nodule-specific proteins, i.e. proteins or polypeptides found only in nodules and not in the subtending roots or other plant-parts. While such proteins may also be of bacterial origin, attention has been focused on those nodulins derived' from the host, in the belief they will provide information on factors involved in nodule formation or nodule function. The most obvious nodulins are the leghaemoglobin proteins (Gibson, 1988). Research has shown that the production of these proteins is under the control of four very similar leghaemoglobin genes located in two clusters (Lba, Lbc1, Lbc3 and a pseudogene; Lbc2 and the second pseudogene) each flanked by regions that cross hybridize (Verma et al., 1984).

Transcription of at least three of these genes commences before the nodules can be observed. A chimeric soybean Lbc3 gene, containing the chloramphenicol acetyl transferase coding sequence, was introduced into *Lotus corniculatus* root-tissue, using *Aqrobacterium rhizogtenes* Ri plasmid (Gibson,, 1988) . Plants derived from this tissue culture were inoculated with *Rhizobium loti* and evidence was obtained for expression of the soybean Lbc3 gene, although only in the nodule tissue (Jensen et al., 1986) . It shows that Lb genes can be transferred and expressed in other legumes.

Over 30 nodulins have been found in developing nodules. Nodulins were identified using extraction of mRNA, which is reverse-transcribed to produce cDNA. The cDNA is used to provide a library of clones, which are further selected on the basis of specificity of reaction with nodule-mRNA but not root mRNA. These probes have been used to study the temporal development of nodulins in nodules formed by effective strains of rhizobia, and by various ineffective mutants on different legume species (Gibson, 1988).

Traits that have been altered, using the molecular tools of genetic engineering, are improvements in competition, enhancement of nodulation, alteration in surface polysaccharide production and host range, energy utilization, bacteriocin production, and nitrogen fixation (Thomas et al., 1997). Genes presumed to be involved in competitiveness have been isolated from *B. japonicum* USDA438 by subtractive DNA hybridization from *B. japonicum* USDA110 (Bhagwat and Keister 1992). Transfer of genes from *B. japonicum* USDA438 to less competent strain, USDA110, increased the competitive nodulation ability of the strain. At the same time, production of antirhizobial compounds, trifolitoxin, by rhizobial inoculant strains could be a useful strategy in limiting nodulation by indigenous strains. The trifolitoxin genes have been cloned and transferred to effective strains of Rhizobium by conjugation of a recombinant plasmid, pTFX1, which possesses the genes for trifolitoxin production and resistence (Triplett, 1988; Triplett, 1990).

(iv) Plant Breeding Methods

The choice of breeding methods is influenced by: 1) the complex nature of the expression of N_2-fixation; 2) trait-heritability; and 3) the destructive nature of many methods for estimating N_2-fixation. The complex nature and moderate to poor heritability of N_2 fixation and related variables suggest that replicated evaluations will help to identify superior genotypes. Replicated family testing also allows for testing against native rhizobia or single inoculant strains, for interactions with added N and, perhaps most important, the evaluation of each family or other important traits, like earliness, adaptation, disease-.reaction and yield (Bliss and Miller, 1988).

The evaluation of families (lines) that can be replicated rather than individual plants, as the units of selection is more efficient (Bliss and Miller, 1988) . On the basis of this consideration, breeding methods that appear to be well-suited for improving N_2 fixation in the legumes are the modified pedigree method (Brim, 1966) and the inbred backcross line method (McFerson et al., 1983). The superior families, selected on replicated family mean-performance, can be released as new cultivars, or used as parents for further crossing.

Nodulation variants, within released cultivars of groundnut, were selected to identify high-nodulating lines to select plants with high nodule number and biomass at harvest, and for growing single-plant progenies in the next year using the pure line selection method. High-nodulating lines consistently maintained superior nodule biomass and gave significantly higher pod-yield than the control, indicating the promise of this technique to obtain high-nodulating lines and yield (Venkateswarlu, 1997).

FUTURE PROSPECTS

Legume host-plant breeding for increased N_2-fixation
seems to be feasible. Host-plant improvement provides both direct and indirect benefits; plants are able to nodulate more profusely and to support larger N_2 fixation values; ***Rhizobium*** superior strains may also be distinguished more easily using a superior host. Further evaluation of legume germplasm for genotypes possessing traits that affect N_2 fixation is needed. Some plant characteristics may limit N_2 fixation. Early maturing determinate plants seem to fix less N_2, than late indeterminate plants with greater leaf-canopy. Significant increases in fixation may be achieved in each plant-type through host-plant improvement, either in relation to an individual superior rhizobial strain or a mixed native population.

Some plant characteristics may not allow large rates of N_2 fixation to be transferred into increased seed yield. Weaver and Miller (1986) reported good and poor fixing mungbean cultivars, which differed substantially in their ability to remobilize N from vegetative tissue to fruits during reproductive growth. If efforts to increase seed-yield by increasing N_2-fixation are to be successful then the genotypes developed should also .be able to partition the increased N into the seeds of legume genotypes.

Comparative yields of plants receiving N-fertilizer are often greater than those fixing N_2 (Bliss and Miller, 1988). Effective breeding for increased N_2-fixation may produce plants as productive as those receiving N. At the same time, there are some evidences that plants and rhizobia differ in their response to the presence of large amounts of external N. This may give an opportunity to develop plants capable of fixing substantial N_2, in the presence of either large or small. amounts of external N, leading to increased productivity.

Work at molecular level in identifying the genes involved in the symbiosis and the incorporation of these genes into either partner may speed up the work to achieve the task of enhancing N_2-fixation in the future.

Development of more competitive rhizobial strains, regular training of extension staff and farmers, using appropriate training- materials, well-planned on-farm demonstrations, and the establishment of Rhizobium inoculum production-centres at provincial levels, are suggested to enhance benefits from this low-cost and environment-friendly technology.

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BULBOUS AND CORMOUS MONOCOTYLEDONOUS ORNAMENTAL PLANTS *IN VITRO*

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ABSTRACT

Literature on bulbous/cormous plants propagated through tissue-cutlure technique is reviewed. Murashige and Skoog (1962) medium (MS) was frequently used to study the different modes of micropropagation. For somatic embryogenesis (SE) explants from aerial parts and somatic organogenesis (SO)/direct somatic organogenesis (DSO) from subterranean parts of the plant were found to be suitable.

Species-wise exhibition of SE, SO and DSO analysed literature is tabulated, showing culture media, growth regulators and organic addenda in primary and secondary medias, relevant explants and the author index.

Effective growth-regulators, their quantity-wise ranges and combinations are also tabulated in terms of percentage, drawing a comparative picture, helpful for their most probable application, to achieve obvious results in quick succession of experiments in the case of newly explored species through in vitro cutlure.

BAP, Kin., 2,4-D and NAA, in different combinations, induced different in vitro features of SE, SO and DSO In the primary culture-medium (1^o) effective range of 2,4-D was 0.1-6.0 mg/L; that of NAA was 0.075-10.0 mg/L; that of Kin was 0.1-4.0 mg/L; and that of BAP was 0.1-3.0 mg/L. In secondary culture mediums (2^o), effective ranges of 2,4-D, NAA, Kin and BAP were 0.5-2.0 mg/L, 0.01-2.5 mg/L, 0.2-2.0 mg/L and 0.5-10 mg/L, respectively.

ABBREVIATIONS

IAA	= **Indole Acetic acid**
2,4-D	= **2,4-Dichlorophenoxyacetic acid**
NAA	**= Naphthelene acetic acid**
PCPA	**= Para chlorophenoxy acetic acid**
IBA	**= Indole butyric acid**
TIBA	**= Tertiary Indole butyric acid**
Pic	**= Picloram**
Kin	**= Kinetin**
BAP	**= Benzylaminopurine**
2-iP	**= Isopentenyl adenine**
GBA & GA_3	**= Gibbrellic acid**
Ade	**= Adenin sulphate**
CH	**= Casein hydrolysate**
CM & CW	**= Coconut water**
Suc	**= Sucrose**
aa	**= Aminoacid**
AC	**= Activated charcoal**

INTRODUCTION

Comparatively, monocotyledons are regarded as difficult *in vitro* material. Initially, Gautheret [1], mentioned only ten monocotyledons out of the hundred odd species to be described for tissue-cutlure. Partenan [2], Castor et al., [3] and Krikorian and Berquam [4] commented on the alleged refractory nature of monocotyledons, as regards *in vitro* culture. Within the last few decades, an increasing number of monocotyledons have been successfully cultured. This included members of the family Graminae and a number of temperate grasses, as well as some bulbous and related species. Bulbs and corms belonging to the Liliaceae, Iridaceae and Amaryllidaceae include species with slow natural propagation e.g. *Hyacinthus* and *Narcissus*, as well as species which can proliferate more freely e.g. *Ornithogallum* and *Ipheion*.

Tissue-culture technology greatly influenced the demand of rapid multiplication and clonal propagation of slow-growing monocots. G. Hussey's work [5] on twelve species of Amaryllidaceae, Iridaceae and Liliaceae establiszhed totipotency in monocots and made a break-through for propagation of ornamentals by tissue-culture. In 1975 Holdgate [6], with co-workers at Twyford Labortories, worked on a number of plants and published numerous papers in the same year.

Thence onwards, several economically important monocot species, whether bulbous, cormous,

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rhizomatous or tuberous, constituting nutritional, medicinal or ornamental groups of plants were investigated *in vitro* for clonal propagation, hybridization [7], disease control [8,9] and production of secondary metabolites [10]. Most of the bulbous and cormous species belonged to the families Amaryllidaceae, Iridaceae and Liliaceae. The explants obtained from storage tissue and growing tissue responded actively. The developing leaves of growing inflorescence stem also responded very well to the growth-regulators and formed plantlets and callus.

The stems of monocotyledons lack a cambium and thus new vascular differentiation after growth due to the apical and intercalary meristem terminates and this limits considerably the possibilities of regeneration. Later on, attempts proved otherwise. The floral stem-tissue transformed into meristematic cells, giving rise to bulblets of adventitious origin. Pierik and Steegmans [11] have reported the regeneration of adventitious sprouts and bulblets on explants of young inflorescence and floral stem explants of *Nerine bowdenii*, N. *sarniensis* and *Eucharis amazonica*. It was thus concluded that floral stem explant could be an excellent source of *in vitro* propagation of Amaryllids.

Although dedifferentiation is relatively rare in monoctyledons, yet there are reports on totiopotency of leaves and buds restricted on floral stalks. There are reports on regenerations of buds and roots on intact or detached leaves and excised leaf fragments of *Heloniopsis orientalis*. Adventitious bud-formation, in etiolated stem segments and in callus tissues arisen from leaf segments of the same, was studied by Kato [12].

Utilization of underground portion of ornamental monocots was introduced by Stone and Holling [13]. Bulblet formation was induced by planting the vertically divided segemnts of the bulbs on suitable culture media. Meanwhile, pieces of single scale with some basal portion were also tried, but the percentage success was just 2 to 3 [14,15,16].

Known chipping technique was introduced by Stone [17] and Stone et al., [18]. The whole bulbs were radially divided into 8 to 16 pieces, each piece consisting of 7-8 scales joined with a piece of basal plate. Formerly, chips were sown in soil in polyethylene bags. Afterwards, soil was replaced with defined cutlure-media for *in vitro* propagated chips [19 & 20].

Twin scaling, the most advanced technique was developed from earlier work on the propagation of *Hippeastrum, Narcissus* and other amaryllids [21]. From one large bulb, 30 - 60 twin scales could be obtained. Each twin scale consisted of two scale pieces, with a small piece of basal plate. The twin scaling technique has been described in detail by Alkema and Leeuwen [22]; Anon [23]; Stone [17]; Stone et al., [18]; and Tompset [24]. It has been successful for a wide range of amaryllidaceous species, as well as for irises and certain Liliaceae [25,26,27,24,28,29 & 30].

Somatic embryogenesis or organogenesis from differentiated tissues of bulbous and cormous monocots is also frequently reported in the literature.

Somatic embryogenesis (SE) through root callus cutlure of rhizomatous irises [31], plantlet regeneration of Gladiolus from inflorescence stalk callus [32] and calli of cormal slices, young leaf bases and whole intact plants was reported by Stefariak [33]. Globular embryos of *Crocus sativus* from callus of meristematic region [34] and plantlets from calli of bud [35] were also reported.

Several species of *Allium* regenerated through callus mediated somatic organogenesis *viz*. A. *sativum* from bud, stem tip and bulbs leaf disc tissue [36,37]; A. *senescences* from flower bud callus [38], somatic organogenesis in Gladiolus cultivars through inflorescence stalk and bud callus cultures [39,40]; similarly *Litium japonicum* and *L. Longiflorum* regenerated through somatic organogenesis (50) from calli of bulblets [41] and mother bulb scale [42] respectively; *Nerine bowdenii* from floral stem callus [11] and *Fritilleria thunberg* had also undergone somatic organogenesis from bulb scale callus [43].

Direct somatic organogenesis (DSO) i.e. organ-to-organ regeneration was also exhibited by several species, such as *Lilium auratum, L.*

speciosum and L. longiflorum formed bulblets on their bulb scales [44]. Bulblets formed on segments of immature floral stem of *Nerine bowdenii* [11], leaves of *Ornithogallum* regenerated shoots [45]. Cormlets formed on young inflorescence stalks of Gladiolus [39]. Multiple shoot formation on substranean shoot apices of *Iris rossii* [46] and shoots regenerated from young inflorescences stalk leaves and immature zygotic embryos of *Freezia refracta* [47].

Bulblet regeneration from chip and twin scale of *Polianthes tuberosa* was reported by Khan et al., [48] and pseudo embryogeney by Naraayanaswamy and Prabhudasai [49] and Zaidi et al., [50].

A detailed survey on micropropagation of crop, non-crop and graminecious species [51] revealed that any one of the species may be regenerated through somatic embryogenesis (SE), somatic organogenesis (SO) (callus mediated) or direct somatic organogenesis (DSO). It was also evident that some species regenerated by two means as well, depending on the nature of the plant and primary and secondary cutlure media. A peer look onto the concise review on ornamental bulbous and cormous monocotyledonous species also indicated similar facts governing their micropropagation. Brief analyses are presented hereforth.

In pursuance to interpret the most probable, applicable culture-medium, source of explant material and effective range of growth-regulator quantities, to establish and micropropagate the bulbous and cormous monocotyledonous ornamental plants the review-cum-analysis of the concerned literature led to the conclusions, suggesting some very likely and helpful parameters to investigate the newer species through tissues-cutlural techniques.

ANALYSIS OF LITERATURE ON ORNAMENTAL MONOCOTYLEDONS*

Culture Media

Among the nutritional media, Murashige and Skoog medium [52] was most frequently used for the monocot species *viz*. *Amaryllis* and *Hippeastrum* [53], *Lilium rubelium* [54] *L. formilonga* [55] and *Leucojum aestivum* [56].

The presented review of *in vitro* studies on monocots is regarding cutlure-media, mode of cutlure, morphogenetic potential of explants and *in vitro* expression of the cultures based on data collected from ornamental bulbous and cormous monocotyledonous species. The information was derived through a literature-survey and included twenty nine *in vitro* cultured species (Table 15). Data analysis, such as, explant source, media or growth-regulator concentration and combinations to ascertain the necessary information for plant regeneration experiments, is based on the lines of Evans, et al. [51].

In literature the following media were mentioned for regeneration of bulbous and cormous monocotyledonous species.

Medium	**Reference**	**Ref.No.**
MS	Murashige and Skoog (1962)	[52]
B5	Gamborg et al. (1968)	[57]
AZ	Abo-El-Nil and Zettler (1976)	[58]
BDS	Modified B5, Dunstan and Short (1977)	[59]
LS	Linsmeir and Skoog (1965)	[60]
Nitsch [61]	Nitsch and Nitsch (1969)	
Nel	Nel (1981)	[45]

Frequency of MS medium used for regeneration through somatic embryogenesis (SE) or somatic organogenesis i.e. direct somatic organogenesis (DSO) and callus mediated somatic organogenesis (SO) of bulbous and cormous monocotyledonous species was found to be maximum. It was 75% for SE, 68.4% for DSO and 69.2% for SO (Table 1). B5 medium [57] was far less frequently employed i.e. only 10.5% for DSO. For SE and SO, B5 was not reported. Frequency of modified B5 medium (BDS) [59] was 23.0% for SO and 8.3% was successful for regenerating the species through SE. Frequency of the rest of the media LS [60], Nitsch [61] or Nel [45] was 5.2% each for DSO. 3.8% Nel medium was employed for SO, but none

* Alliums were also included, as they comprised a number of species investigated *in vitro*

for SE. Regeneration of species through SO and SE on LS or Nitsch mediums was not reported.

Modes of Culture

For regeneration of ornamental monocot species, micropropagation through stationary (agar solidified or mounted on a paper bridge), suspension or both culture techniques have been reported. However, *Tissue Cultures* were more generally established on agar solidifed mediums, as reported for establishment of *Crocus sativus* [34] and *Lilium Longiflorum* [62].

Organ Culture of monocotyledonous plants included quiescent buds from underground storage organs, as in case of *Narcissus* [63], axillary buds of the floral stalks e.g., *Nerine bowdenii* [64] and shoot apices of subterranean parts e.g. *Iris rosii* [46]. Evidence of shoot multiplication in both solid and liquid agitated medium was reported for *Lilium auratum, L. speciosum*, and *L. longiflorum* [44]. Bulb scales of *L. rubelium were* cultured on modified MS liquid and agar mediums, behaved differently, as the growth of bulbs was enhanced in liquid medium [54]. *Gladiolus* bud explants when cultured in liqiuid agitated medium formed plantlets [40].

The technique of cell culture was generally applied for clonal propagation and production of secondary metabolites. Cell cultures of *Iris siberica* and *Polianthes tuberosa* were established for the production of essential oils and polysaccharides, respectively [10,65]. Cell-suspension cutlures of *Gladiolus* cultivars established with friable calli, regenerated plantlets from two month old suspensions [32].

Protoplast culture, usually applied for somatic hybridization of known species to create new varieties, was also reported for certain monocotyledonous bulbs. Creamy white calli with embryogenic potential were induced from the seeds of *Lilium formilonga* compact cell clumps formed in liquid medium of the same composition. Protoplasts isolated from meristematic nodular clumps were successfully colonized and then planted in gellengun solidified medium, which then formed shoots and roots [55].

Morphogenetic Potential of Explants

Morphogenetic potential of the plants cultured *in vitro* depended on the nature of the explant, age of the organ and status of the donor plant. Explants are generally obtained from the parts which retain meristematic activities.

Bulbous, cormous, tuberous, rhizomatous and pseudobulbous ornamental monocots are perennial herbaceous plants, which propagate by specialized vegetative structures. Aerial and underground parts of the plants regenerate annually. Almost all parts of the plant from 'root to inflorescence tip' have been reported in literature as being utilzied as a source of explant.

Parts of the bulbs, stem, leaf, basal plate and carpels of endangered plants *Lilium rhodopoeum* and *Leucojum aestivum* [56] were cultured *in vitro*. The basal part of the bulbs of former and leaves of the latter possessed highest regenerative activity.

Tissue cultures of *Fritillaria thunbergii* were obtained from the various parts of the plant during germination stage. The bulb cells showed a higher growth potential than cells from root, stem or leaf [43].

Segments of young inflorescence, young leaves and immature zygotic embryos of *Freezia refracta* were cultured by Wang et. al. [47]. Morphogenetic response of the explants, either directly or mediated through callus, depended on the exogenous hormonal conditions in the cutlure media. Ishioka and Tanimoto [30] successfully induced differentiation in bulb scale segments, cultured cells and leaf segments of *Lilium longiflorum*.

Root and leaf pieces from *in vitro* grown plants of several genotypes of rhizomatous *Iris spp*. were cultured *in vitro*. Callus induction occured only on root cultures. Somatic embryogenesis, which occurred in regeneration medium, was reported by Genvieve et al. [31].

Azuma and Yokoyama [66] used leaf explants of *Iris palleda* for regenerating whole plants. *Ornithogallum maculatum* was rapidly propagated *in vitro* from leaf tissues, provided the donor plants, of which the first floret had opened [67].

Induction of Adventitious buds on undetached leaves, excised leaves, leaf fragments and, in etiolated stem segemnts of young *Heloniopsis orientalis* plants were reported by Kato [12,68]. Culture of young flower stalks of *Narcissus tazetta* was reported as an efficient explant source by Hosoki and Asahira [35].

Relation between differentiation and phytohormones in scales of *Lilium daviaii* was determined by Yang et. al., [69]. The upper part of the scale had no differntiating ability, lower and middle parts however differentiated at a frequency of 80 and 10 percent respectively. It was assessed that differentiating ability in different parts of the Lily bulb scale was closely related to the contents of the endogenous growth regulators.

Inflorescence stalk of *Gladiolus* plants cultured on MS basal salts media formed compact type of callus that regenerated plantlets [32].

Excised stamens of *Lilium rega* were grown *in vitro* to obtain haploids from its pollen grains. Another sac, connective tissue, and filaments showed variable proliferative capacities and organogenic potentialiites [70]. Calli were formed on the cut ends of the filament, while the buds embedded in the callus formed plantlets in continuous light.

Table-2 shows a variety of explants used in regeneration experiments on bulbous and cormous monocots. The frequency of regeneration as SE, SO and DSO indicated the morphogenetic potential of the explants.

In literature, almost every part of the whole plant was employed for *in vitro culture*. From top to root, six groups of explants were identified belonging to aerial and sub-terrestrial zones of the plant (Table-2). Shoot apex and axillary buds on floral stem belonged to group 1 of Aerial Zone. Group 2 of the same zone comprised floral stem, peduncle, inflorescence segments, flower bud, carpel, stamen/filament and mature/immature embryo served as a source of explant. Group 3 to 6 belonged to Subterrestrial Zone of the plant. Explant from mother bulb scale, bulb scale and leaf base/leaf blade were gathered in group 3. Fourth group explants were obtained from the meristematic region, twin scales, basal plate, corm slice and shoot bases. Bulblets, cormlets and young pseudobulblets constituted the group 5 explant source. Roots were the only organ providing group 6 explants.

Regenerative potential of explants of group 1 of Aerial Zone was 22% SE, 17% SO and 10% DSO, that of group 2 explants of the same zone was 31% SE, 26% SO and 14% DSO (Table-2).

Group 3 explants of underground zone expressed the potential of regeneration in terms of percentage i.e. 15,31 and 29 for SE, SO and DSO respectively. Frequency of Regenerative potential of explants of groups 4 and 5 was 15 and 8 each and 12, 33 and 14 percent for SE, SO and DSO respectively. Root expalnts exhibited only SE which was 8% (Table 3).

In Vitro Expression of Culture

Phenotypic expression of culture *in vitro* depends on modified behaviour of the explants in the pretext of genetic format induced by micro environment, comprising medium constituents including growth regulators and physical factors. Differentiated culture may redifferentiate via callogenesis or directly through organogenesis. Adaptation of a pathway for a variety of morphological, biochemical, physiological and genetic expression, normally commences with a prelude to sterile culture establishments.

Plant Regeneration

Growth regulator concentrations in the culture medium are critical to the control of growth and morphogenesis. Generally, a high concentration of auxin and a low concentration of cytokinin in the medium promotes abundant cell proliferation with the formation of callus. Often 2,4-D is used to initiate callus. On the other hand, low auxin and high cytokinin concentration in the medium results in the induction of shoot morphogenesis. Auxin alone or with a very low concentration of cytokinin is important in the induction of root primordia.

Embryogenesis

General and specific information pertaining to the culture regimens for initiation of SE for the bulb and corm species have been summarized in Tables-3,4,5 and 6. Table-3 shows species which have undergone somatic embryogenesis. Information regarding culture media, growth regulator for primary and secondary media (1^o and 2^o medium) and the explants, being mentioned with particular references, respectively.

It was notable that *Ca* 30% of species had somatic embryogenesis, originating from explants excised from distil end of the floral stem, comprising shoot apices, rachis and floral parts. 75% of the explants cultured on MS medium or on mofidication of MS medium (Table-2). These medium regimens included 2,4-D in 83.3% primary culture mediums and Kin, in 50% of the primary culture mediums. NAA was used in primary culture mediums to lesser extent at a frequency of 33.3% (Table-4). Effective concentration ranges for these growth regulators were 0.1-6.0 mg/L for 2,4-D, 0.1 - 1.0 mg/L for Kin., and 0.075-10.0 mg/L for NAA (Table -6). Although, 2,4-D was used more frequently (Table-5) but range of NAA concentration was wider than other ones *viz* pCPA, Pic., BAP, Kin., and 2iP (Table-6). In primary culture media, occasional use of casein hydrolysate and coconut water was also reported.

The culture media used for induction of embryo development during secondary culture (20) of bulbous species contained growth regulators, while the 2^o mediums for the cormous species were devoid of growth regulators. In secondary culture media, growth regulators other than 2,4-D and NAA were used. IAA at a concentration range of 1.75-2.0 mg/L, Kin., 0.2-2.0 mg/L and BAP 1.0-10 mg/L with other additives, GA_3, adenine sulphate and ascorbic acid, were supplemented in the media (Table-6).

Examination of Table-5 revealed that 2,4-D alone or in combination of one or two cytokinins dominated the list of growth regulator combinations such as 2,4-D with pCPA, NAA and/or BAP. In 50% combinations 2,4-D was present. In secondary culture mediums 2,4-D was not required in any concentration. Kin was present with the combination of IAA, TIBA or alone in 14.2%, 7.1% and 9.7% respectively in 2^o mediums. BAP alone was present in 14.2% secondary culture mediums and in combination with GA_3, TIBA and Pic, at a frequency of 7.1% each (Table-5).

Organogenesis

In vitro data of ornamental monocotyledonous species with specialized stems, show that 56% of them exhibited somatic organogenesis and 50% species manifested direct somatic organogenesis. MS medium was [52] equally important and popular for inducing direct somatic organogenesis (DSO) i.e. 68.4% and 69.2% respectively as compared to somatic embryogenesis (Table-1). Frequency of BDS [59] medium was 23.0% for callus mediated somatic organogenesis.

Explants from bulb/crom rachial portion of the floral stem (Group 2) and scale/leaf (Group 3), had undergone 26% and 31% callus mediated somatic organogenesis. Table-2 indicates direct somatic organogenesis by the explants excised from scale/leaves (Group 3) and basal disc or meristematic region (Group 4) of the bulbs/corms. Frequency of direct somatic organogenesis from group 3 and 4 explant was 29% and 33% respectively.

Callus mediated somatic organogenesis being comparable to somatic embryogenesis in case of primary and secondary culture mediums, either of the two (1^o and 2^o mediums) were necessary for regeneration among monocotyledonous bulbous and cormous species (Table-7). It was the direct somatic organogenesis of the same species that was sometimes expressed after a subculture on secondary culture medium. This type fo feature is not common among the dicotyledonous and graminecious species.

Somatic Organogenesis

Growth regulator regimen in primary and secondary cutlure mediums for somatic organogenesis included IAA, IBA, 2,4-D NAA, pCPA and Pic, among the auxins. Whereas Kin, BAP and 2iP from the cytokinin group were prominent in the Table-8, showing frequency of individual growth regulator supplemented in primary and secondary culture mediums. 2,4-D was individually present in 40.7% primary and 22.2% secondary culture mediums. The other important auxin, NAA was 33.7% in 1^o mediums and 29.6% in 2^o mediums.

Among the cytokinins, BAP and Kin were present frequently. Frequency of BAP was 3-4 times more than Kin. in primary and secondary culture mediums, i.e., 51.8% in 1^o medium and 48.1% in 2^o medium, while those of Kin were 18.5% and 11.1% respectively.

The Table-9 shows that combinations of 2,4-D or NAA supplements with other growth regulators in primary culture mediums for somatic organogenesis were almost equal. But BAP with either of the two was more frequently used i.e. 2,4-D + BAP 14.8% and NAA + BAP 18.5%. In secondary culture medium, combination of 2,4-D with BAP was equally important and its frequency was again 14.8% as that in primary culture medium, NAA remained important in 2^o medium. Cumulative frequency of NAA with BAP and certain additives or Kin. was 25.9%.

There are 14.8% secondary culture mediums which were devoid of growth regulators. 11.1% primary cutlure mediums are sufficient for somatic organogenesis of bulbous and cormous monocotyledonus species.

Table 10 shows range of 2,4-D concentration in 1^o mediums i.e. 0.5-5.0 mg/L and 0.5-2 mg/L in 2^o mediums. NAA range in primary and secondary culture mediums was 0.01-10.0 mg/L and 0.01-2.5 mg/L respectively. Among the cytokinins, Kin. and BAP were 0.1-4 mg/L and 0.1-16 mg/L respectively in primary culture mediums, but 0.5-2.0 mg/L and 0.5-4.0 mg/L respectively in secondary culture mediums.

Among the other additives range of sucrose was more than 3% i.e. 5% and 5-7% in 1^o and 2^o culture mediums respectively.

Direct Somaatic Organogenesis

Table - 11 shows species that have undergone direct somatic organogenesis and were influenced by a limited, yet very much known, members of the auxins and cytokinins such as IAA, IBA, 2,4-D and NAA; Kin., BAP and 2iP respectively. Among the auxins, NAA was present in 63.1% and BAP in 73.6% primary culture mediums (Table 12). Frequency of 2,4-D was 10.5% and Kin. 15.7% in 1^o media. Rest of the auxins were far less frequent. In 2^o culture media, only NAA, BAP and 2iP were used at a frequency of 10.5% each.

Supplementation of additives for direct somatic organogenesis was not required for the bulbous/ cormous species, as observed in literature.

For induction of DSO there were six combinations of NAA and BAP, five of Kin., two each of 2,4-D and 2iP and three each of GA, and sucrose (Table-13). Frequency of 1^o culture medium with a successful combination of growth regulators i.e., NAA and BAP was 31.5%. Next combination was that of BAP with sucrose present in 10.4% mediums.

Frequencies of 2^o media with NAA and BAP/2iP or BAP and 2iP were only 5.2% each. 20.8% secondary culture mediums were devoid of growth regulators. For 57.8% regeneration of several species via callus mediated somatic organogenesis secondary culture mediums were not required.

Overview of bulbous and cormous species exhibiting somatic regeneration is shown in Table-15 i.e., 56% species expressed somatic organogenesis SO *in vitro*. 50% had direct somatic organogenesis (DSO), while 30% species regenerated throguh somatic embryogenesis (SE).

CONCLUSION

Inclusion of 2,4-D, NAA, Kin. and BAP into MS medium was found to be remarkably suitable for both somatic organogenesis as well as somatic embryogenesis.

Explants from aerial zone of the plants were suitable for somatic embryogenesis (SE). The explants from floral stem and mother scales were good for somatic organogenesis (SO), while mother bulb scale and twin scale explants from sub-terrestrial zones exhibited direct somatic organogenesis (DSO).

Among the growth regulators 2,4-D, Kin, NAA and BAP were found to be employed in cutlure mediums in different combinations to study various features of micropropagation i.e. SE, SO and DSO. 2,4-D alone or in combinaton with Kin and/or NAA supplemented in primary or secondary culture mediums was effective for callogenesis and SE. Combination of BAP with 2,4-D/NAA in primary and secondary culture mediums was effective for SO. BAP with NAA and occasionally sucrose in primary culture mediums promoted DSO.

Range of growth-regulator quantities i.e. 0.1-6.0 mg/L for 2,4-D; 0.015-10.00 mg/L NAA; 0.1-4.0 mg/L Kin. and 0.1-30.0 mg/L BAP were observed in primary culture mediums. However, 0.5-2 mg/L 2,4-D; 0.01-2.5 mg/L NAA; 0.2-2.0 mg/L Kin. and 0.1-10 mg/L BAP were effective growth-regulator concentrations in secondary culture mediums.

Table 1: Frequency of Culture Media used for Regeneration of Bulbous and Cormous Monocotyledonous Species *In Vitro*

Media	Somatic Organogenesis		Somatic (SE) Embryogenesis
	Direct	Callus Mediated	
MS	68.4%	69.2%	75.0%
B5	10.5%	--	--
BDS	--	23.0%	8.3%
AZ	--	3.0%	8.3%
LS	5.2%	--	--
Nitsch	5.2%	--	--
Nel	5.2%	8.8%	--

Table 2: Frequency of Somatic Embryogenesis and Organogenesis (Callus Mediated and Direct) Exhibited through *in vitro* Culture of Explants of Monocolyledonous Bulbous and Cormous Plants

Explants From	Regenerants		
	Somatic Embryogenesis (SE)	Somatic Organogenesis (SO)	Direct Somatic Organogenesis (DSO)
Aerial Zone			
1. Shoot apex	22%	17%	10%
Axillary bud			
2. Floral stem	31%	26%	14%
Peduncle			
Inflorescence segments			
Flower bud			
Carpel			
Anther			
Embryo			
Sub-terrestrial Zone			
3. Mother bulb scale	15%	31%	29%
Bulb scale			
Leaf base			
4. Meristematic region			
Twin scale	15%	12%	33%
Basal plate			
Corm slices			
Shoot base			
5. Bulblet	8%	12%	14%
Cormlet			
Pseudobulb			
6. Root	8%	--	--

Table 3: Bulbous and Cormous Monocotyledonous Species Capable of Somatic Embryogenesis (SE) after Primary and Secondary Culture

Bulbous Species	Growth Regulators and Organic addenda (mg/L)		Medium	Explant	Reference	Ref.No.
	Primary medium 1º	Secondary medium 2º				
Allium sativum	2.0 pCPA 2.2 2,4-D 0.10 Kin	0.2 Kin 1.75 IAA	AZ	Bud Stem tip basal leaf disc	Abo-El-Nil and Mustafa, (1977)	36
A.sativum	0.1 2iP 0.5 NAA 0.1 2,4-D	10.0 BA		Shoot tip	Choi, (1993)	37
A. fistulosum X *A. cepa*	0.75 Pic 2.00 BAP 90.00 CH	0.75 Pic 2.00 BAP 25.0 Glycine 25.0 Proline+Vit.	BDS	Basal plate	Lu et. al., (1989)	72
Iris setosa	A B 5.0 2,4-D 1.0 2,4-D 1.0 Kin 1.0 Kin 1.0 GA_3 250 Proline 250 Proline 250 CH 250 CH 5% Suc. 5% Suc.	1.0 BAP 100 Ade 2% Sucrose	MS embryo	Mature	Radojevic and Subotic (1989)	73
Iris SPP *(Rhizomatous)*	1.0 2,4-D 0.075 NAA 0.1 Kin or 5.4 2,4-D or 0.075 NAA 0.1 Kin	2.0-5.0 BAP or 1.0 Kin 2 mMTIBA 2.0 BAP 2 mMTIBA	MS	Root (1991)	Genevieve etl.al	31
Polianthes *tuberosa*	2.0 2,4-D 1.0 Kin 6.0 2,4-D -- 15 %CW 2.0 2,4-D --	-- --	MS	Bract/ petal Ibid Ibid	Narayanaswamy & Prabhudesai (1979)	49
Cormous *Gladiolus cu* *Jennylee*	10 NAA 0.5 Kin	2.0 Kin or None	MS	Basal Leaf	Kamo (1994)	74
Gladiolus	2,4-D	None	MS	Inflore scence stalk	kamo et. al. (1990)	32
Crocus sativas	2.0 2,4-D 0.5 Kin	2 IAA 2 Kin 100 Ascorbic	MS	Merist- ematic region	George et al.	34

Table 4: Frequency of Individual Growth Regualtors Supplements in Primary and Secondary Culture Mediums Supplemented to Initiate Somatic Embryogenesis (SE) in Monocotyledonous Bulbous and Cormous Species

Growth	Primary Culture Medium (1°)	Secondary Culture Medium (2°)
Auxin		
1 AA	--	16.6%
2,4-D	83.3%	--
NAA	33.3%	--
pCPA	8.3%	--
TIBA	--	16.6%
Pic.	8.3%	8.3%
Cytokinin		
Kin	50.0%	33.3%
BAP	8.3%	41.6%
2iP	8.3%	--
Others		
GA_3	--	0.3%
Ade	--	0.3%

Table 5: Frequency of Specific Growth Regulator's Supplements and or Combination in Primary and Secondary Culture Mediums used for the Somatic Emrbyogenesis (SE) of Bulbous and Cormous Monocotyledonous species

Growth Regulators	Culture Mediums for Somatic Embryogenesis	
	Primary Culture Medium (1°)	Secondary Culture Medium (2°)
IAA + kin	--	14.2%
2,4-D	16.6%	--
2,4-D+pCPA+Kin.	8.3%	--
2,4-D + Kin.	16.6%	--
2,4-D + Kin. + CH	8.3%	--
2,4-D + Kin. + NAA	16.6%	--
2,4-D + NAA	8.3%	--
2,4-D + CW	8.3%	--
Pic. + BAP	--	7.1%
Pic. + BAP + CH	8.3%	--
NAA + Kin.	8.3%	--
BAP	--	14.2%
BAP + GA_3 + Ade.	--	7.1%
BAP + TIBA	--	7.1%
Kin. + TIBA	--	7.1%
Kin.	--	7.1%

Table 6: Growth Regulator Concentration Range in Primary and Secondary Culture Mediums used for Induction of Somatic Embryogenesis (SE) in Monocotyledonous Bulbs and Corms

Growth Regulators	Effctive Concentration (mg/L)	
	Primary Culture (Medium (1°)	Secondary Culture Medium (2°)
1 AA	--	1.75 - 2
1 BAP	--	--
2,4-D	0.1 - 6	--
NAA	0.075 - 10	--
pCPA	2	--
Pic.	0.75	0.75
BAP	2	1 - 10
Kin.	0.1 - 1.0	0.2 - 2
2iP	0.1	--
TIBA	--	2 - 4 μM
GA_3	--	1.0
Ade.	--	100
Ascorbic acid	--	100
CH	250	--

Table 8: Frequency of Individual Growth Regulator Supplements in Primary and Secondary Culture Medium inducing Somatic Organogeneis (SO) through Calli of Bulbous and Cormous Monocots/ledonous Plants

Growth Regulators	Callus Mediated Somatic Organogenesis (SO)	
	Primary Culture Medium (1°)	Secondary Culture Medium (2°)
1 AA	--	7.4%
IBA	3.7%	--
2,4-D	40.7%	22.2%
NAA	33.3%	29.6%
pCPA	3.7%	--
Pic.	3.7%	3.7%
TIBA	--	--
Cytokinin		
Kin	18.5%	11.1%
BAP	51.8%	48.1%
2iP	3.7%	--
Others		
GA_3	--	3.7%
Ade	3.7%	--
Media with growth retardants	--	--
Media with no growth regulators	3.7%	22.2%

Table 9: Frequency of Specific Growth Regulator Supplements on Combination of Primary and Secondary Culture Media used for Somatic Organogenesis (SO) of Bulbous and Cormous Monocotyledonous Species

Growth Regulators	Direct Somatic Organogenesis	
	Primary Culture Medium (1º)	Secondary Culture Medium (2º)
IAA + kin	--	3.7%
IAA + Kin. + Ascorb	--	3.7%
IBA	3.7%	--
2,4-D	3.7%	--
2,4-D + NAA	3.7%	--
2,4-D + Kin.	3.7%	3.7%
2,4-D + Kin. + pCPA	3.7%	--
2,4-D + Kin. + Suc + CH	3.7%	--
2,4-D + BAP	14.8%	14.8%%
2,4-D + BAP + CM	3.7%	3.7%
2,4-D + 2iP + NAA	3.7%	--
NAA	--	3.7%
NAA + BAP	18.5%	11.1%
NAA + BAP + Ade.	3.7%	--
NAA + BAP + CH	--	3.7%
NAA + BAP + Suc	--	3.7%
NAA + Kin.	7.4%	3.7%
Pic. + BAP + aa	--	3.7%
Kin.	--	3.7%
BAP	3.7%	3.7%
BAP + GA_3	--	3.7%
Growth inhibitors	3.7%	--
No growth regulators	--	14.8%
No 2º medium	--	11.1%

Table 10: Growth Regulator Concentration Range in Primary and Secondary Culture Mediums used for Somatic Organogenesis (SO) for Regeneration of bulbous and Cormous Monocotysyledonous Species

Growth Regulators	Concentration Range (mg/L)	
	Primary Medium (1º)	SecondaryMedium (2º)
1 AA	--	1.75 - 2
1 BAP	10	--
2,4-D	0.5 - 5.0	0.5 - 2
NAA	0.01 - 10	0.01 - 2.5
pCPA	2	--
Pic.	0.75	0.75
Kin.	0.1 - 4	0.5 - 2.0
BAP	0.1 - 16	0.5 - 4.0
2iP	0.1	--
GA_3	--	0.1
CH	90 - 250	100.0
Ade.	62.5	--
CM	2%	2%
Ascorbic acid	--	100
Sucrose	5%	5 - 7%

Table 11: Monocot Yledonous Bulbous and Cormous Species Capable of Direct Somatic Organogenesis (DSO) through Primary and/or Secondary Culture

Species	Growth Regulators Organic addenda (mg/L)		Medium	Explant	Reference	Ref. No.
	Primary Medium (1°)	Secondary Medium (2°)				
Bulbous						
Allium sativum	0.1 NAA 9-12 % Suc	None	-	Vegetative bud	Park *et al.*, (1993)	85
	2.0 NAA 4.0 BAP 4.0 2,4-D	-	MS	Bulblet	Sub & Park, (1993)	77
A.tuberousum	0.5 BAP 0.5 2iP	0.5 BAP 0.5 2iP	B5	Halved shoot base	Panday *et al.*, (1992)	86
	1.0 NAA 0.5 2iP	1.0 NNA 0.5 2iP	B5			
Iris spp.	16.0 IBA 0.1 2,4-D	None	MS	Mature embryo	Stoltz (1977)	87
	2.0 Kin. 12.0 GA3	None	MS	Emryo	*Ibid.*	
I. rossii	0.2 NAA 5.0 BAP	-	MS or Nitsch	Shoot apex	Furuya (1992).	46
Leucojam aestivum	1.0 BAP 1.0 Kin.	-	MS	Leaf	Stanilova *et al.*, (1994).	56
Lilium daviaii	1 1AA 0.4 µMBA 0.3 µMGA$_3$	-	-	Bulb scale	Yang *et al.*, (1989).	70

Table - 11 (Cont'd)

Table 11 Cont'd

Species	Growth Regulators Organic addenda (mg/L)		Medium	Explant	Reference	Ref. No.
	Primary Medium (1°)	Secondary Medium (2°)				
Lilium rhodopeaum	0.5 NAA 0.1 Kin.	- -	LS	Basal plate	Stanilova *et al.*, (1994)	56
Lycoris aurea	3.0 NAA 30.0 BAP	3.0 NAA 10.0 BAP	MS	Twin Scale	Huang & Lila (1989)	29
Ormithogallum maculatum	2.0 NAA 2.0 BAP 3.0 % suc	-	Nel	Leaf	Rensburg *et al.*, (1989)	67
Narcissus	2-16 BAP 0.25-4 NAA	-	MS	Bulbscale leaf	Hussey, (1982)	63
N.tazetta cv Geranium and fortune	5 BAP 1 NAA	- Ring & Nitsch	MS + Plate	Overy, leaf, basal (1980)	Hosoki & Asahira,	69
N.tazetta cv Grand Soleil d Or	6 BAP 1.0 NAA 3 % Suc 0.5 % AC	-	MS	Twin scale	Stenitz and Yahel, (1982)	28
Dendrobium	0.1 NAA 0.1 BAP		MS	Pseudobulb	Yasugi & Shinto (1994)	88
Cormous						
Gadiolus dalenii	2 BAP 3 % Suc	None	MS	Corm slice	De Bruyn & Ferreire, (1992).	89
G. trista	0.5-1.0 BAP 6-9 % Suc	6-9 Suc only	MS	Corm slice	*Ibid.*	

Table 12: Frequency of Individual Growth Regulator Supplements in Primary and Secondary Culture Medium in Initiation of Somatic Organogenesis induced Directly in Bulb and Corm Forming Monocotydedonous Plants

Growth Regulators	Direct Somatic Organogenesis	
	Primary Culture Medium (1º)	Secondary Culture Medium (2º)
Auxins		
1 AA	5.2%	--
IBA	5.2%	--
2,4-D	10.5%	29.6%
NAA	63.1%	10.5%
pCPA	--	--
Pic.	--	--
TIBA	--	--
Cytokinin		
Kin.	15.7%	--
BAP	73.6%	10.5%
2iP	10.5%	10.5%
GA_3	70.6%	--
Ade.	--	--
Media with growth retardants	--	--
Media without growth regulators	--	--

Table 13: Frequency of Specific Growth Regulator's Supplements and Concentration in Primary and Secondary Culture Mediums used for Direct Somatic Organogenesis (DSO) of Monocotyledonous Bulbs and Corm forming plants

Growth Regulators	Culture Media for Direct Somatic Organogenesis	
	Primary Culture Medium (1º)	Secondary Culture Medium (2º)
IAA + kin + GA_3	5.2%	--
IAA + BAP + GA_3	5.2%	--
IBA + 2,4-D	5.2%	--
2,4-D + Kin +BAP	5.2%	--
NAA + Kin.	5.2%	--
NAA + BAP	31.5%	5.2%
NAA+BAP+Suc.	5.2%	--
NAA+BAP+Suc.+AC	5.2%	--
NAA + Suc.	5.2%	--
NAA + 2iP	5.2%	5.2%
Kin. + BAP	5.2%	--
Kin. + GA_3	5.2%	--
BAP + 2iP	5.2%	5.2%
BAP + Suc.	10.4%	--
Suc.	--	5.2%
None	--	20.8%
2º Medium		57.8%

Table 14: Growth Regulator Concentration Range in Primary and Secondary Culture mediums used for Direct Somatic Organogenesis (DSO) in Monocotyledonous Bulbous and Cormous Plants

Growth Regulators	Concentration ange (mg/L)	
	Primary Culture Medium (1º)	Secondary Culture Medium (2º)
1 AA	1.0	--
1 BAP	15.0	--
2,4-D	0.1 - 1.0	--
NAA	0.25 - 3.0	1 - 3.0
Kin.	0.1 - 2.0	--
BAP	0.1 - 30.0	0.5 - 10.0
2iP	0.5	--
Suc.	8 - 12%	6 - 9%

Table 15: *In Vitro* Regenerated Bulbous and Cormous Species

Species	Mode of Somatic Regeneration		
	SE	DSO	SO
Allium Sativum	✓	✓	✓
A. fislulosum and S.L. epa	✓		✓
A. tuberouse			
A.Senecens			✓
A.trifolium hirsulam			✓
Iris setosa	✓		✓
I. spp.	✓	✓	
I. rossii		✓	
Lilium japonicum			✓
L. longiflorum			✓
L. daviaii		✓	
L. rhodopeaum		✓	
Gladiolus sp.	✓		✓
Gladiolus dalenii		✓	
G. trista		✓	
G. cv jannylee	✓		
Narcissus cv.		✓	
Narcissus spp.		✓	
Narcissus tazetta		✓	✓
Crocus sativas	✓		✓
Lycoris aurea		✓	
Leucojam aestivum			
Ornithogallum maculatum		✓	
Fritilaria thunbergi			✓
Nerine bowdenii			✓
Muscari armenicum			✓
Hippeastrum hybrid			✓
Plianthes tuberosa	✓		
Dendrobium		✓	

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NETWORK ACTIVITIES
NODE: FOCAL POINTS OF MEMBER STATES

NATIONAL UNIVERSITY OF SCIENCE AND TECHNOLOGY, ZIMBABWE

A BRIEF NOTE

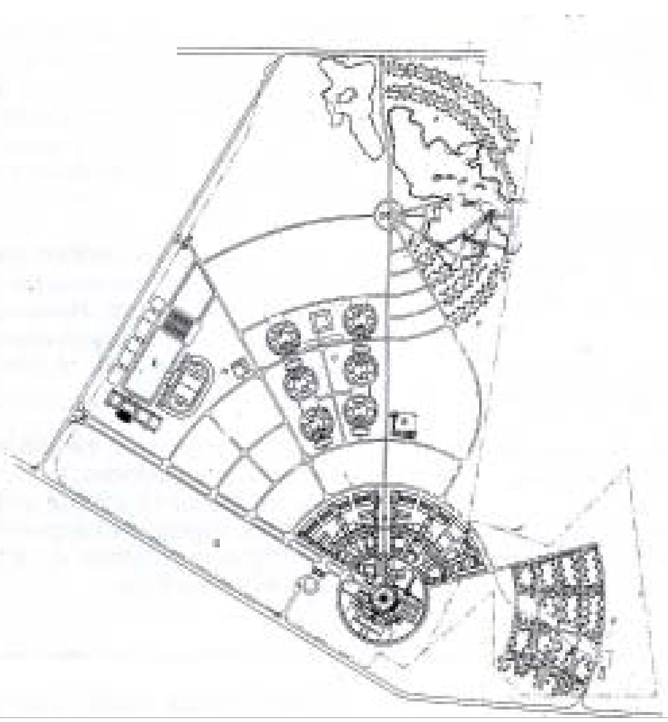
The National University of Science and Technology was founded in 1991, following a Government-sponsored commission of enquiry into the establishment of a second University in the country. Prior to that, the University of Zimbabwe was the only state-run university in the country. The need for a second university came about after the realization that the University of Zimbabwe did not have a technological thrust and industrial bias. Therefore, the establishment of NUST was in direct response to the technological needs of Zimbabwe. The ultimate aim was to produce academic graduates with proven technological skills and industrial experience.

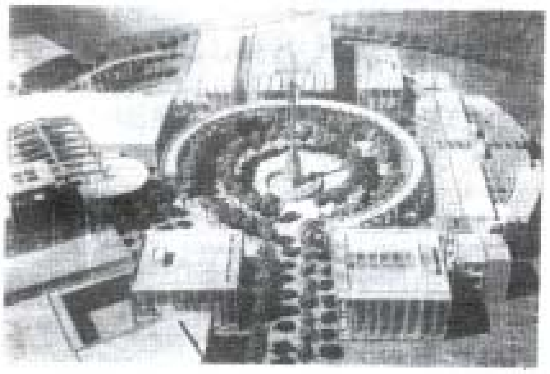
To build a university to fulfill these aims was an extremely difficult and complex task. For a start, there was no similar institution to consider for guidance. Secondly, details of the buildings themselves were very sketchy and it needed expereinced personnel to design the buildings. This process led to the development of a Master Plan and a catalogue of building design briefs. As shown on the attached drawing, the master plan proposed buildings covering the entire development of the University Campus.

DEVELOPMENT PROJECTS

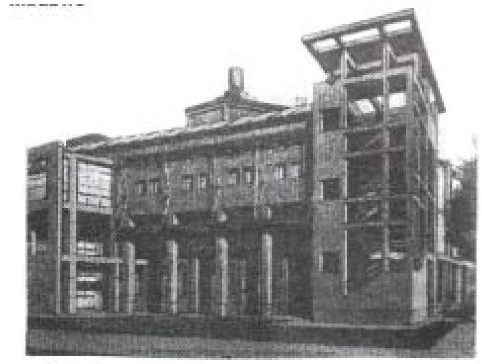
The University Campus is designed to have the followign facilities and programmes:

1. Administration Block with 200 offices
2. General-Purpose Hall with a capacity for 2000 people
3. Central Library
4. Shopping mall with restaurants, banks and cinema
5. Faculty of Commerce with five departments and MBA school
6. Faculty of applied sciences with the following departments:
   (a) Applied Chemistry
   (b) Applied Biology and Biochemistry





Model View of the Central Plaza Buildings



View of the Industrial Technology Faculty from Pedestrian Boulevard

(c) Applied Physics
(d) Applied Mathematics
(e) Computer Science

7. Faculty of Industrial Technology with the following departmental blocks:
   (a) Chemical Engineering
   (b) Industrial Engineering
   (c) Civil and Water Engineering
   (d) Electronic Engineering
8. Faculty of Architecture and Quantity-surveying with the following departments:
   (a) Architecture
   (b) Quantity Surveying
9. Faculty of Environmental Sciences
10. Faculty of Communication and Information-Technology
11. Faculty of Art, Education and Social Sciences
12. Central Stores and Maintenance
13. Students Union
14. Student Residences
15. Staff Housing

In 1991 the total cost of building and equiping the institution detailed above was estimated at Z$500 million (about US$100 million). In view of the depreciating Z$, the project is now estimated at Z$15 billion.

This was a mammoth task and the project had to be phased. The first phase had the following projects:

1. Administration Block, 2. Faculty of Commerce
3. Applied Chemistry, 4. Chemical Engineering
5. Central Library, 6. Ceremonial Hall
7. Shopping mall, 8. Student Residences
9. Applied Physics, 10. Civil and Water Engineering
11. Central Stores and Maintenance
12. Architecture and Quantity Surveying

This project was to be wholly funded by the Zimbabwe Government, but a recession in the 1990s created budgeting problems. The only projects started in phase one have been:

Administration Block	*1993*	(now complete)	
Faculty of Commerce	*1994*	(now complete)	
Applied Chemistry	*1994*	Chemical Engineering	*1995*
Student Residences	*1995*	Central Library	*1997*
Shopping Mall	*1998*	Ceremonial Hall	*1998*

Of these projects only two have been completed and handed over and these are the Administration Building and the Faculty of Commerce.

The harsh marco-sitaution in the country has made it extremely difficult to make reasonable progress on this project. We are thus forced to seek funding from sources other than the Government of Zimbabwe which has other serious finanical problems. We, therfore, welcome any assistance from anybody in whatever form.

The delayed completion of NUST has made it difficult for the academics to progress their research to the level that they would like. However, credit must be given to them for the research and development that they have accomplished, to date, under difficult conditions.

The next challenge, once the buildings are complete is to equip the laboratories. In view of the fact that this is an institution of science and technology, it is important that appropriate equipment is also provided. We also welcome donations, in cash and kind, to help us equip these buildings.

SCIENCE AND TECHNOLOGY NEWS

COMSATS NEWS

WORKSHOP ON USE OF SPECTROSCOPIC TECHNIQUES IN STRUCTURAL ORGANIC CHEMISTRY, HELD AT HEJ RESEARCH INSTITUTE OF CHEMISTRY, KARACHI

The workshop on this subject was held on February 14-21, 2000. During the workshop, it was emphasized that one of the most important milestones in modern science was the development of spectroscopic techniques. Spectroscopy is a tool, which can unravel the inner contents of any sample regardless of its origin. It, therefore, acts as the eyes and ears of modern science. The uses of spectroscopy in biology, medical diagnosis, industrial analysis, environmental probing and other fields are already widespread. From pollution-monitoring to forensic investigations and from structure-determination of natural molecules to assessing the quality of industrial raw materials, spectroscopy provides the most efficient and cost-effective means of analysis.

The main objective of the “HEJ-COMSATS Workshop on the Use of Spectroscopic Techniques in Structural Organic Chemistry” was to provide an opportunity to young and upcoming chemists to learn the effective use and operation of modern spectroscopic instruments. During this workshop, attempts were also made to develop special skills in the interpretation of spectroscopic results and their utilization in quantative and qualitative analytical work.

The programme of the Workshop included lectures, practical training, interpretation exercises and problem-solving sessions. Participants of 14 countries representing Bangladesh, Cameroon, Egypt, Ghana, Iran, Palestine, Kazakhstan, Nepal, Mongolia, Pakistan, Sri Lanka, Sudan, Uganda and USA, benefitted from the worskhop.

COMSATS DELEGATION VISIT TO TWAS, ITALY, FROM MAY 23-31, 2000

A delegation, comprising the Executive Director and Director Planning, visited TWAS, Italy, from May 23 to 31, 2000, in a bid for promotion of science and technology applications in common member states. COMSATS has made a big stride in the field of Science and Technology striving its object of motivating the COMSATS member countries towards the centrality of Science and Technology in development of overall economic and social uplift. TWAS & COMSATS have agreed to reinforce the cooperation between them for enhancing the pace of Science and Technology development in COMSATS countries, through a Memorandum of Understanding, the first of its kind in the scientific history of the country. Dr. Hameed Ahmed Khan, Executive Director signed on behalf of COMSATS and Prof. M.H.A Hassan, Executive Director, TWAS inked the agreement at Trieste, Italy, on May 26, 2000.

TWAS would extend all help to the member states involved to induce adequate resource-allocation for research and development, as well as to integrate Science and Technology in national and regional developments.

COMSATS would establish a Coordinating office at its Headquarters in Islamabad and would represent TWAS in the member countries for smooth implementation of the provisions of the memorandum. The two international science organizations have also resolved to set up an information centre in member states as well as the co-organization of joint activities to effectively work under this historic memorandum of understanding.

The salient features of the memorandum comprise emphasis on consultation and cooperation among the two organizations in order to reinforce development activities in research work undertaken by scientists and science organizations of member states. It aims at mutual exchange of information for securing long-term financial support from international donor agencies, as well as provision of publications on scientific topics of common interest.

The Memorandum highlights the use of the premises of COMSATS & TWAS to ensure effective dissemination / transmission of information on each others development projects, for the benefit of member states, and to help exchange and sustain scientific research in various scientific institutions of the member states.

COMSATS DELEGATION VISITED IPC IN VIENNA

The COMSATS delegation, comprising Executive Director and Director Planning, visited Vienna, Austria, in connection with formal signing of MOU on science and technology cooperation between (IPC) UNIDO, based in Vienna, and COMSATS. The proposed agreement would be broad-based, to facilitate the concerned parties to come closer to sort out different details including terms and conditions, etc, as well as the scope of cooperation. The proposed MOU would be based on terms to be decided on case-to-case basis, covering activities such as joint ventures, organization of show cases/exhibitions, collaboration in environmental information and management, the possibility of publishing joint publications, initiative of IPC(UNIDO) to promote contacts with COMSATS, jointly funded research projects etc.

THE R&D ENGINEER CAN NEVER WIN

The R&D Engineer's work is finally to be witnessed and vouched by all. If he makes a mistake, he cannot

Like the doctor, bury it, or

Like the architect, obscure it by trees or ivy,

LIKE THE LAWYER, BLAME IT ON THE JUDGE OR JURY,

Like the politician, blame his constituents,

Like the Minister, change the name of it and hope that the voters will forget,

LIKE THE PLANNERS, ATTRIBUTE IT "TO CHANGE OF PLANS" BY EXECUTIVES,

Like the Executives, Label it "the resources-constraint" and

Like the clergyman, cannot blame the devil.

(Contributed by Engr. Rafiq Hussain, Pakistan. Telecom Authority)

SCIENCE AND TECHNOLOGY NEWS

NATIONAL NATURE-CONSERVATION ZONE FOR THE YARLUNG ZANGBO GRAND CANYON

Master Plan of Yarlung Zangbo Grand Canyon National Nature-Conservation Zone has recently passed the approval check of experts from Chinese Academy of Sciences. As a result, a national nature conservation zone will be created in the Canyon.

The nature-conservation zone in the plan will be located in the southeast section of Tibet, with a total area of 9600 Km^2 and a population of 14,900. During the period from October 19 to December 10, 1998, a scientific expedition team, composed of over 60 scientists from diversified disciplines such as geology, geography, atmospheric physics, botany and zoology, had successfully walked through the Canyon for the first time. Through this unprecedented expedition, scienitsts have found that the maximum height of the peaks standing at the sides of the Canyon reached over 7700 meters, the sea level of the river 2000 meters or lower, at 400 or 500 meters in some areas, registered a world record of height-difference by 5000 meters. The Yarlung Zangbo Canyon has been officially confirmed as the largest of its kind in the world.

The Canyon has rich geological and natural landscapes, with four huge falls running through the trunks of the Yarlung Zangbo River. The Canyon's unique geological and climatic features have bred its unqiue ecological system and rich flora and fauna resources with many rare plants, animals and insects. So far more than 3000 plants have been classified as higher plants and more than 40 species as rare animals under national protection. Sitting at the northeast corner of Indian and Eurasian plates, the Canyon has been given honourable names, such as "natural museum of biological resources", "genetic bank of biological resources" and "geological museum".

The Master Plan has outlined comprehensive measures protecitng flora and fauna and geological characteristics in the Canyon and made the divisions of conservation areas and species under protection. It is also reported that to tap the rich water-resources in the Canyon on a rational basis, the concerned authorities will establish a hydraulic observation station in the Canyon, so as to prepare for the future power generation at the Yarlung Zangbo River.

CHINA'S SOPHISTICATED BURN-TREATMENT TECHNIQUES

Humid ointment representing the world's advanced techniques for burn treatment, was officially approved (approval file number: Z20000004) by China State Pharmaceutical Supervision Administrator for mass production. This has demonstrated China's world advanced level in burn treatment and its potential contributions to the world's people, through research results of series products.

At present, the improvement of traditional burn-treatment approaches has become a dominant trend. As a result, biomedical communities, businesses and governments in many countreis have invested huge resources in seeking for fetus-like no-scar treatment result through taking advantage of the latest technical means and man's own physiological skin-repair functions. Self repair oriented burn-treatment has become popular in the area.

The so-called humid therapy, invented by Prof. Xu Rongxiang, China Burn Injury Treatment Centre, is an innovative burn-treatment system. His representative technique (MEBT) and products (MEBO) have successfully handled four major clinical difficulties, such as wound pain, infection, progressive necrosis and scar-healing of grade II burns. His products have monopolized the market for a decade. When the western world invested huge resources in studying physiological self skin repair techniques and associated products, China's burn treatment techniques have already acheived attractive clinical results.

It took a decade for Prof. Xu Rongxiang to achieve fine results from his studies of skin-cloning and he has successfully applied his research-results in self skin-repair therapy for patients with large burn wounds. In his studies of anti-infection treatment of extensive and deepened burns, he has worked out new anti-infection approaches humoring the ecological conditions and structures of microbes, rather than using bacteria killing or oppression techniques, and achieved clinical success for extensive burns. It is important to note that humid therapy invented by Prof. Xu is still in the process of diffusion and improvement. It is reported that the blue book on burn-treatment techniques, to be published by China Association of Chinese Traditional and Western Medical Sciences, will reveal a number of completely new research results on self skin repair therapy.

(*Courtesy: China Science and Technology, Newsletter No. 216, March 10, 2000*)

THE SMALLEST HELICOPTER IN THE WORLD

Developed by Shanghai Jiaotong University, a mini-helicopter, which is able to take off and land on a spot of only two peanuts size, made its debut in Shanghai. Being the smallest and lightest helicopter in the world, the dual-propeller flying machine has a length of only 18 mm, height of 5 mm and weight of 100 mg. When the rotation speed reaches 21,000 per minute, the helicopter body will be trembling up into the air.

A year ago, a German company announced the birth of the world's smallest helicopter at that time with a length of 24mm, height of 8 mm and weight of 400 mg.

As briefed by researchers, the smaller the length and the lighter the weight of the helicopter, the wider applications it can find. Manufacturing the mini-helicopter has covered high technologies in a variety of fields such as special materials, mini-mechanical processing, electronics, air dynamics and others, and is of great difficulty.

(*Courtesy: China Science and Technology, Newsletter No. 216, March 10, 2000*)

CANCER PATIENTS NEED HEALTHY FOOD TO COMBAT SIDE-EFFECTS

A nutritious diet is always vital for your body to work at its best, but it is more important for people with cancer. Patients who eat well during their treatment are able to cope better with the side-effects of treatment. Patients who eat well may be able to handle a higher dose of certain treatments.

A healthy diet can help keep up your strength, prevent body-tissues from breaking down, and rebuild tissues that cancer-treatment may harm.

When you are unable to eat enought food or the right kind of food, your body uses stored nutrients as a source of energy. As a result, your natural defenses are weaker and your body cannot fight infection as well. Yet, this defense system is especially important to you now, because cancer patients are often at risk of getting an infection.

A good rule to follow is to eat a variety of different foods everyday. No one food, or group of foods contains all of the nutrients you need. A diet to keep your body strong will include daily servings from these food groups:

Fruits and Vegetables: Raw or cooked vegetables, fruits, and fruit juices proivde certain vitamins (such as A and C) and minerals the body needs.

Protein Foods: Protein helps your body heal itself and fight infection. Meat, fish, poultry, eggs, milk, yogurt, and cheese give you protein as well as many vitamins and mineras.

Grains: Grains, such as bread, pasta, rice, and cereals, proivde a variety of carbohydrates and B vitamins. Carbohydrates provide a good source of energy, which the body needs to function well.

Dairy Foods: Milk and other dairy products provide protein and many vitamins, and are the best source of calcium.

Doctors know that pateints who eat well during cancer treatment are better able to cope with side-effects. However, there is no evidence that any special kind of diet or food can either cure cancer or stop it from coming back.

In fact, some diets may be harmful, especially those that don't include a variety of foods.

(*Courtesy: Daily Pakistan Observer, Monday, May 15, 2000*)

SOYBEAN KEY TO A HEALTHY HEART

Soybean contains protein that may lower cholesterol levels, which can lead to a reduced risk of heart disease. Soy, as a component of Asian diets, has long been associated with a reduced risk of cardiovascular illness. More recently, the United States Food and Drug Administration has approved the labelling of soy- products as significant for chlesterol lowering.

Monash University's cardiovascular researchers lead the largest controlled trial performed to date of soy on the cardiovascular system. The study, on 220 men and women, confirms that soy lowers fatty lipids, including cholesterol. The study also discovered that soy may even help lower blood-pressure slightly.

The scientists believe that soy contain isoflavones, which are quite active ingredients. They are a sub-group of agents known as phytoestrogens: plant-based compounds that mimic the female hormone oestrogen, which is thought to proivde a protective effect against heart-disease.

Isoflavones are found in soy as well as other foods, such as the plant red clover. Armed with this theory, the Baker Institute has carried out two studies on 50 women, using isoflavones extracted from red clover and from soy, or a placebo.

The Baker researchers, led by Professor Paul Nestel, found that women who took isoflavones had significantly improved elasticity of the arteries; equivalent to that experienced by women on hormone replacement therapy.

Separate research at the Baker Institute, by doctors Chin Dusting and Krishna Sudhir, using a synthetic form of isolfavones, has shown improved artery-flow and prevention of early arterial atherosclerosis, the disorder causing heart attacks.

(*Courtesy: Daily Pakistan Observer, Monday, May 15, 2000*)

AEROBIC EXERCISE BENEFICIAL FOR ELDERS

Vigorous aerobic exercise may be the best way to improve cardiovascular health of people who are in 60s and 70s age-groups.

In a study of 117 healthy men and women, aged 59 to 77, investigators found that the subjects' aerobic capacity, rather than the number of calories they burned through exercise, was strongly linked to heart-disease risk.

The men and women who had the greatest aerobic capacity were leaner and had lower cholesterol and insulin levels compared with their peers, report Dr. Eric T. Poehlman, of the University of Vermont in Burlington, and colleagues, in the Journal of Clinical Endocrinology and Metabolism.

Those who were aerobically fit - a measure of the body's ability to transport and use oxygen - appeared to be at lower risk of heart-disease regardless of whether or not they exercised more or less than other study subjecs. This, Poehlman said, suggests that bursts of exercise that get the heart and lungs working at peak capacity may benefit elder hearts more than frequent, moderate activity.

With a doctor's approval, he noted, some elderly people may be better off engaging in vigorous exercise. According to Poehlman and his colleagues, there has been considerable controversy about how much older men and women should exercise, and what types of activity they should engage in.

It has not been clear which is more important - aerobic fitness or calorie - burning exercise. The authors note that these two factors do not necessarily go hand-in-hand.

To directly compare the two factors, the researchers measured the subjects' aerobic capacity on a stationary bike and guaged their calorie-burning over 10 days. They also looked at participants' body composition and dietary intake over 3 days.

The men and women were then divided into groups based on high and low aerobic capacity, and high and low calorie-burning. Across all groups, the investigators found that participants' activity levels surpassed the general recommendation that older adults burn about 200 calories each day through exercise. Yet, only those with high aerobic capacity showed a reduction in many heart disease risk factors.

(*Courtesy: Daily Pakistan Observer, Sunday, April 16, 2000*)

AIDS VIRUS CAN HIDE IN 'T CELLS'

The Aids virus can hide in the body, immune to the most powerful drugs, making it likely that it will be many years before a cure is found. Research by microbiologists at the University of Minnesota shows that within three days of infection, the HIV virus can invade "resting T-cells".

Scientists are of the view "these cells are good hiding places because they are inactive and so ignored by the body's immune system. Neither can they be attacked by drugs, which need some kind of activity by the virus or the cells it infects in order to work. "No drug currently available could find the virus in its hiding place and kill it, the scientsts added.

Ashley Haase, reporting the findings in the journal Science, said: "These cells fly below the radar screen of the immune system. They also live a long time and won't be affected by our current combination of anti-Aids drugs".

HIV causes illness by infecting immune-system cells, known as CD4 T-cells. When the virus gets inside, it take over a cell's machinery and makes it crank out copies, killing the cell. As long as this is happening the body's other immune-cells can detect the activity and attack, while drugs can stop various stages of the takeover process.

This explains why cocktails of HIV drugs can help to suppress the virus.But the research shows that HIV is also able to enter inactive or "resting" T-cells, which can exist in the body for years, even decades, without doing anything.

Mr. Haase's team, working on monkeys and later HIV patients, discovered that the virus can invade, within three days of infection, before symptoms are shown.

Dr. Anthony Fauci, head of the National Institute of Allergies and Infectious Diseases, said that the study helped to explain why people who took cocktails of drugs for years were not cured.

(*Courtesy: Daily Pakistan Observer, Wednesday, April 12, 2000*)

HORMONE THERAPY INCREASES HEART-RISK

A latest study, involving thousands of postmenopausal women found that hormone-replacement therapy increases the risk of heart problem slightly, but the risk appears to fade after two years. The potential benefits and risks of taking estrogen as a hormone supplement have been examined repeatedly these last few years, with many stuides indicating that estrogen improves memory, reduces the risk of heart-disease in pre-menopausal women, alleviates menopausal symptoms such as hot fluhes, and lowers osteoporosis risk.

But high estrogen-levels have also been associated with breast cancer, and its effects on the heart in postmenopausal women have been unclear.

Preliminary findings from the federally funded Women's Health Initiative suggest postmenopausal women, taking estrogen during the first two years of treatment, face a slightly elevated risk for a heart attack, stroke or blood clot, comapred to similar women taking a placebo. The study isn't scheduled to end until 2005, so researchers say that risk could change over time. Only 1 percent of the 27,000 women participating in this portion of the study suffered a heart attack, stroke or blood clot, although exact figures have not been released.

It's long been known that estrogen can raise the risk of blood clots, although there's been some question as to who is most at risk. Health experts caution that it's too early to use these findings as a basis for determining who should take estrogen, and that doctors and patients should make such decisions on an individual basis.

(*Courtesy: Daily Pakistan Observer, Tuesday, April 11, 2000*)

IODINE DEFICIENCY AFFECTS INTELLIGENCE

Salt-iodization protects millions of new-born every year from a ten percent loss in learning ability. Iodine-deficiency affects intelligence and the ability to learn. It is the world's single greatest cause of preventable severe mental retardation, UNICEF Executive Director, Carol Bellamy, told participants at the opening ceremony of Salt 2000, the 8th World Salt

Symposium at the Hague.

“Where populations are suffering from iodine-deficiency, average intelligence can spiral downwards by approximately ten IQ points”, Bellamy said. “This has serious implications, not only for individuals, but also for the social and economic development of entire nations”.

Bellamy praised the salt industry for its crucial role in salt-iodization and the key partners in the effort - international agenices, Kiwanis International, donor governments and NGO’s.

Bellamy told the meeting that two major tasks remain to be accomplished. The first is to reach the 30 percent of the world’s population that does not have access to iodized salt. The second is to sustain the progress already achieved.

“In many countries of Eastern Europe and the Commonwealth of Indepedent States, iodization-rates have dropped dramatically in recent years. This experience has taught us that we cannot be complacent. Iodine deficiency is an ever-present threat to the development of children”.

Bellamy called on the salt industry to support implementation of the iodization legislation - now on the books in most countries. She urged all producers to help improve the production, quality and availability of iodized salt in the developing world, through such initiatives as encouraging salt-production in developing countries.

(*Courtesy: Daily Pakistan Observer, Monday, May, 8, 2000*)

HIGH LDL CAUSE OF HEART AILMENT

Blood cholesterol plays an important part in deciding a person’s chance or risk of getting coronary heart disease. The higher your blood-cholesterol level, the greater your risk. Cholesterol is a waxy substance found in all parts of your body. It helps make cell membrances, some hormones, and vitamin D. Cholesterol comes from two sources: your body and the foods you eat. Blood chlesterol is made in the liver.

The liver makes all the cholesterol your body needs. Dietary cholesterol comes from animal foods, like meats, whole-milk dairy foods, egg yolks, poultry and fish. Eating too much dietary cholesterol can make your blood cholesterol go up. Foods from plants, like vegetables, fruits, grains and cereals do not have any dietary cholesterol.

Low-density lipoprotein (LDL) cholesterol or “bad” cholesterol carries most of the cholesterol in the blood, which leads to buildup of cholesterol in the arteries. High-density lipoprotein (HDL) - cholesterol or “good” chlesterol helps remove cholesterol from the blood and helps prevent the fatty buildup.

LDL narrows the arteries and can slow down or block blood-flow to the heart. With less blood, the heart gets less oxygen. With not enough oxygen to the heart, there may be chest pain (“angina” or “angina pectoris”), heart attack (“myocardial infarction”), or even death.

A high blood-cholesterol level is not the only thing that increases your chance of getting heart-disease; cigarette smoking, high blood pressure, diabetes, obesity/over-weight, physical inactivity are other elements. Beside these, the uncontrollable factors: 45 years or older for men, 55 years or older for women, family history of early heart disease (heart attack or sudden death) are also responsible.

Lowering cholesterol slows the fatty buildup in the arteries, and in some cases can help reduce the buildup already there. And, if you have two or more other risk factors for heart disease, or already have heart disease, you have a great deal to gain from lowering your high blood-cholesterol.

High intake of saturated fat, dietary cholesterol, and excess calories, leading to overweight, can increase blood cholesterol levels.

(*Courtesy: Daily Pakistan Observer, Tuesday, April, 4 2000*)

TOMATOES MAY HALT CANCER PROGRESS

Tomatoes, which are already acknowledged to have a preventative action against cancer, may actually halt its progress, according to a leading specialist.

The vegetable has been found to prevent the disease by providing high levels of lycopene, a powerful antioxidant, which is responsible for the red colour.

Dr. Venket Rao, professor of nutrition at the University of Toronto, found that breast and prostrate cancer sufferers had low levels of lycopene. The 20 men and 18 women then drank 500 ml of tomato juice twice a day for a month and their lycopene levels, measured in blood and tissue, shot up.

Dr. Rao said that this indicated that the increased lycopene may slow down the progression of the tumours: people with cancer tend to have poor absorption of lycopene. He announced these and other findings at a conference at the Nutrition Food and Health Research Centre in Kings College, London. The professor said lycopene could be the "master switch" to diseases such as cancer and coronary heart problems. By giving excessive lycopene, doctors might be able to control the switch.

He said: "There is some evidence that lycopene not only plays a part in prevention but it can also slow the growth of a tumour. In addition to being preventative, it can be prophylactic. His findings were welcomed by nutritionists and horticulturalists, although cancer specialists warned that randomised clinical trials were needed to confirm Dr. Rao's analysis.

Prof. Gordon McVie, of the Cancer Research Compaign, who last year advised people to make one of their daily five portions of fruit and vegetables a tomato because of its protective qualities, said: "A lot of cancer lumps can consume nutrients, to the detriment of the rest of the body. You can eat what you like but the cancer gets it. Dr. Rao has shown that you can overcome that by raising lycopene levels".

But he cautioned that it could not be assumed that cancer would slow down if lots of tomatoes were consumed. He said: "There's some good circumstantial evidence, but it requires a very careful study. I don't think that primary schools should necessarily rush out and put tomatoes on the menu".

(*Courtesy: Daily Pakistan Observer, Monday, April, 3 2000*)

CHOLESTEROL LEVEL HAS A LINK WITH GENES

One of the main reasons why some people's cholesterol levels are more responsive to dietary changes than others: the answer appears to be in your genes.

According to the study, published in the American Journal of Clinical Nutrition, a group of northern Finns with a specific genetic makeup, called a genotype, showed much greater increases and decreases in LDL cholesterol levels, in response to diet than others without the genotype.

LDL is considered the "bad" type of cholesterol because it can build up on the walls of arteries that feed the heart and brain and cause clogging, or arterosclerosis. Should the buildup lead to a clot in an artery, the result can be either a heart attack or a stroke. There is also "good" cholesterol, called HDL, which is believed to actually help carry bad cholesterol from the liver, where it is passed from the body.

The genotype pinpointed in the study is related to a protein called apolipoprotein B, which plays an essential role in lipid transport and the way the body processes cholesterol. It is also associated with an increased risk of cardiovascular disease.

In studying the protein, researchers with the University of Oulu in Finland and the Hebrew Univeristy of Jerusalem screend the lipid-related phenotypes of 22 men and 22 women, all employees of a Finnish hospital who volunteered for the study. The subjects' cholesterol levels were then monitored for six months, during which time their diet was regulated to rotate from low-fat to high-fat at monthly intervals.

The results showed that participants with one genotype in particular, the "XX-" genotype, had the greatest increases in LDL cholesterol during the high-fat diet and the greatest decreases during the low-fat diet. Those with two other genotypes, "M+/M+" and "R-/R" also showed greater increases and decreases in cholesterol in relation to diet.

The American Heart Association (AHA) recommends that a desirable total cholesterol level is less than 200 miligrams per deciliter of blood. Cholesterol levels between 200 and 239 are considered a high-blood cholesterol level. The AHA recommends that HDL, or "good" cholesterol, levels be above 35 milligrams per deciliter.

(*Courtesy: Daily Pakistan Observer, Sunday, April, 9 2000*)

YOUTH EQUALLY PRONE TO CHOLESTEROL HAZARDS

Staying away from high-fat, high-cholesterol foods is not just a warning for adults to heed. A new study of teen-agers found that one-third of them had increased their heart-disease risk factors with junk food diets that could lead to high blood-pressure and clogged arteries, as they grow older.

The American College of Cardiology has published these fidings in a recent report.

Researchers at the Pacific Health Education Centre in Bakersfield, California, and Prevention Concepts, evaluated the dietary habits and cardiac risk profiles of more than 200 high school students. More than 80 percnet of them consumed higher than recommended levels of total and saturated fat, while dietary cholesterol was excessive in 49 percent.

Cholesterol levels were considered abnormally high for the age in one-third of the participants, and approximately one in 10 had systolic hypertension, a form of high blood-pressure.

To compare high-risk teens with their healthy counterparts, researchers used ultrasound to measrue the thickness of the neck's primary artery, the carotid artery. Teenagers with the thickest artery walls were likely to be those who were oveweight or had high blood pressure or high cholesterol - all common risk factors for heart-disease in adulthood. Thickening of the areries is not dangerous in itself, but a build up of small fatty deposits can be an early indicator of arterosclerosis - an abnormal thickening of artery walls.

(*Courtesy: Daily Pakistan Observer, Friday, April, 7 2000*)

7TH INTERNATIONAL SYMPOSIUM ON ADVANCED MATERIALS (ISAM - 2001) ISLAMABAD, PAKISTAN 17-21 SEPTEMBER 2001

Scope of the Symposium

The 7th International Symposium on Advanced Materials (ISAM-2001) will be held in Islamabad, Pakistan, from 17-21 September 2001. This biennial event has become a popular and probably one of the prime international forums, at which materials-engineers and scientists can keep up-to-date with recent technologies concerning adanced structural and functional materials. Contributions are welcome on the following topics:

TOPICS

1. ***Production and Processing:*** Melting and refining, near-net shape technology, sintering. Joining of materials. Physicochemical aspects of glass-ceramic-metal joints. Adhesive bonding. Evaluation of joints.

2. ***Characterization and Quality Assurance:*** Characterization techniques for special steels, super-alloys, nano-crystalline, light alloys piezoelectric, electronic, magnetic, optical and bio-medical materials, superconductors, ceramics, glasses, composites, polymers, etc. Thermo-mechanical treatments, phase transformations, texture analysis, destructive and non-destructive evaluation of materials.

3. ***Materials Performance and Life Prediction:*** Selection, compatibility and service behaviour of materials. Fracture, failure analysis, life prediction of structures, modeling, numerical techniques, material design and artificial intelligence.

4. ***Surface Modifications and Degradation:*** Shot peening, organic, thermal sprayed, optical and photo-conductive coatings. Erosion/wear-resistant coatings. Interaction of coatings with environments Thermodynamic aspects of corrosion, SCC, corrosion protection and hydrogen embrittlement.

Languages

English is the official language of the symposium

Deadlines

Submission of Abstract	February 28, 2001
Notification of acceptance	March 31, 2001
Submission of manuscript	May 31, 2001
Last date for registration	July 31, 2001

Symposium Secretariat

Please address all enquiries to:

Dr. A.A. Mazhar
Secretary Symposium
Dr. A.Q. Khan Research Laboratories, Kahuta,
P.O.Box 905, Rawalpindi, Pakistan
Tel: Office: 92-51-9280541
Residence: 92-51-281307, 92-51-250229
92-51-280954,
Fax: 92-51-9280542, 92-51-9280164
Email: compudiv@isb.paknet.com.pk

BUSINESS OPPORTUNITIES, FAIRS AND EXHIBITIONS

INTERNATIONAL MUSLIM EXPO (1-5 NOVEMBER 2000)

The High Commission of Pakistan, in Bander Seri Begawan, Brunei, has informed that they are planning to open a Display Centre of Pakistani Products in the premises of the High Commission in order to introduce Pakistani Products effectivey into the local market. They proposed to organize an International Muslim Expo from 1 to 5 November, 2000, in Brunei, and have requested the Pakistani manufacturers/exporters to send their products and brochures for display purposes. The interested members may also indicate a reserve price of their products Muara Port, Bandar Seri, Bagawan, Brunei. For further information and necessary advice. Pakistan High Commission, P.O.Box 3026, Bandar Seri Bagawan, Negara Brunei Darussalam.
Tel: (673)-2-339797, 334989
Fax: (673)-2-334990

INDONESIAN TRADE EXHIBITIONS PROGRAMME-2000

RCCI has received a copy of the Indonesian Trade Exhibitions Programme - 2000, including International Exhibitions, National Exhibitions and Local Exhibitions, which will be held in Jakarta, Indonesia, this year. For any further information, you may contact the following address: Indonesian Exhibition Companies Association, Trade Mart Building, 3rd Floor, Room 330-C, Arena Prj-Kemayoran, Jakarta-10620. Indonesia.
Tel: (62-21) 421 8341 - 421 8342
Fax: (92-21) 421 8341
Email: info@ieca.or.id

ENVIRONEX

The 1st International Environment Exhibition, ENVIRONEX Philippines, on 02-05 October 2000, at the Philippine Trade Training Centre, Manila. ENVIRONEX Philippines will showcase state-of-the-art technologies in environment, solid-waste management, air-pollution control, noise abatement, recycling, waste-water treatment, pollution measurement and analysis systems, aerial surveillance, cleaning systems, dredging, plumbing, waste disposal, flood control and drainage system. Suite 1004, Goldhall Tower, #5 Inopolis Sirect. Greenhills, San Juan 1500, Metro Manila. For details please contact: MARIE P. ATCHADA, Vice President-Operations.
Tel: (632) 724-2679/726-9293/725-1505/725-1909
Fax: (632) 723-9389
Email: adsi@iconn.com.ph

(Courtesy: RCCI News Bulletin No. 6/ 2000 dated March 16, 2000)

PROMOTE YOUR BUSINESS IN AMERICA

We act as agent, you may ship your merchandise on self consignment basis and sell it yourself in New York. Open your Branch Office in New York, we will proivde you all the information and assistance concerning the formation of your company. We will display the samples, distribute your catalogues and price-list in major trade-shows in America, at nominal charges for order booking.
American Trade Centre Inc. 303 Fifth Avenue, suite 817, New York NY 10016.
Fax: (212) 725-0187/(212) 725-0458
Email: amtrade@usa.com

EXPORT OPPORTUNITY

We intend to import Dried ROSE Flowers and SPICES. Those interested may contact: (Laurant Boutros) Purchase Manager Ets. Mohammed Khaled Hassouneh
Fax: 0096 11 735 201-009611 251 869
Email: sounehix@cyberia.net.lb

TRADE DELEGATION TO USA

16-member Leather-Garment manufacturer/exporters delegation will visit USA in 2nd week of October, 2000. For appointments, please contact 212-472-6123.
Email: paktrade@mail.idt.net

LIST OF NEW CONTACTS IN USA

M/s Paulina Boye. 22 Faraway Road, Armonk,
NY 10504
Tel: 914-273-3692, Imports: Towel, Athletic Socks, Bed Sheets

Mr. Jerry Crown. C.N. Enterprises Inc.
Fax: 520-299-7294, Imports: Denim/ Polo Shirts
Mr. Francisco Agcaoill, World Manufacturing and Trading Corp.
920 Austin Lane # B. Honolulu, HI 96817
Fax:808-848-8636
Imports: Canvas, Poly Cotton Fabrics

M/s Fashion Business Corp
1466 Broadway # 1004, New York, NY 10036
Fax: 212-764-46655
Imports: Cotton yarn

Mr. Naustein, Supply Plus in 35 Martin Luther King **Jr.** Blvd. Newark, NJ 07104 Fax: 973-481-7775
Imports: Cotton Mope

M/s Import Export Ltd.
117-11 Jamaica Avenue, Richmond Hill, NY 11418, USA
Fax: 718-849-5099
Imports: T-Shirts, Jeans, Leather Products

M/s Ali Khan Design Inc.
389 Fifth Avenue Suite 402, New YOrk, NY 10016, Fax: 212-685-2111
Imports: contume Jewellery, Fashion Accessories

Ms. Lynn Maclean, M/s. Marmaka Group
Worcestor, MA, Fax: 508-390-5850
Imports: Woven Bedsheet

Mr. Benjamin Ayayee
365 East, Marion Avenue, Apport 113,

Bronx 10458, USA, Fax: 718-733-1986
Imports: Rice

PROMOTING PAKISTAN'S EXPORTS

The British Importers Bureau have invited the Pakistani exporters to develop trade-relations with Great Britain.

They are also publishing the British Importers Review, which is made available to the most important companies and importers in Great Britain and the EEC, needing to regularly review their sources of imports. The Review offers the following:

- Help to those wishing to export into Britain
- Guidance to British business, keeping them abreast of new sources of supply, new products and new exporters from countries.

Interested members may contact Mr. Peter Andrews. Director, British Importers Bureau, Administrative Centre, P.O.Box 1443, London W1A 9LB
Fax: (+44) 020-8314-1933
Email: britishimportersbureau@yahoo.co.uk

OPPORTUNITIES FOR BUSINESS AND INDUSTRIAL COOPERATION WITH KYRGYZSTAN

We have the pleasure to reproduce below extracts from the report of the Pakistan Ambassador at Bishkek, Republic of Kyrghzstan, for your information:

1) The worsted-spining factory "Kasiet" was constructed in 1977. The full capacity of the factory is 3.5 million kg of woollen yarn per year. Wool of the Kyrgyz merino sheep is used as raw material. The Director showed interest in establishing links with Pakistan for the purchase of the raw material.

2) The Director expressed intention to visit Pakistan to familiarize himself with the work of the poultry farms. He also wanted to explore the possibilities of importing feed for broiler chickens from Pakistan.

3) Deputy Head of the Regional State Administration expressed that they were ready to start business cooperation with Pakistan, particularly in poultry, vegetables and fruits-processing and livestock breeding.

4) A number of industrial units, like eletronic plant producing semi-conductors, linoleum and textile factory, were not in operation. The Deputy Head is interested to find Pakistani partners for joint ventures. Those interested in establishing business and industrial cooperation with Kyrgyzstan, in the above-specific fields, should contact FPCCI.

PARTNERS REQUIRED

Vetagro International also offers its customers/agents with local technical assistance through seminars, technical formations and field studies. We are presently seeking to establish new partnerships for our animal-nutrition and animal-health products in Pakistan. We are looking for new potential distributors/agents. Those interested may contact us. S. Makovski, Commercial Director, Vetagro International, Tour Lilleurope-Parvis de Rotterdam-59777 EURALILLE-France
Fax: (33) 3 20 55 35 65
Email: makovski@vetagro-intl.com
Website: http://www.vetagro-intl.com

BUSINESS WITH SAUDIA

M/s Arab Pesticide Industries Company (MOBEED), Saudi Arabia, which is ISO 9002 certified, is the leading pesticides formulator in the Kingdom of Saudi Arabia and is the supplier of high-quality pesticides for agriculture, public health and domestic use on an international scale. M/s MOBEED is looking for reputable Pakistani Companies, who are interested in buying agrochemical products. Interested parties may contact at the following address:
Mr. Sami M. Eid, Managing Director, Arab Pesticide Industries Co., P.O.Box 11539, Jubail Industrial City 31961, Kingdom of Saudi Arabia.
Fax: (966) 03 358 6192, Email: seid@xenel.com

IMPORT OPPORTUNITY

M/s Esfahan Chemical Industries produces many different chemicals, and it has various research projects to produce the necesary chemicals for different industries because it possesses sophisticated equipments and technical possibilities. Most of the above research projects have enhanced good results and now we are producing new products and we are thinking of producing them in abudance.

While considering the above matters, please if you are willing, send us a summary of activities of your esteemed company to provide the opportunity of mutual cooperations.
R. Davary, Sales Manager
P.O.Box 159 Zarrinshahr, Esfahan, I.R. Iran,
Telefax: +98(31) 222139, +98(334632) 2702

(Courtesy: RCCI News Bulletin No. 6/2000 dated March 16, 2000)

INTER CLEAN GULF '2000 (OCTOBER 17-20, 2000)

M/s Al Madina Exhibition WLL, Bahrain are organizing the Inter Clean Gulf '2000, Cleaning Industry International Exhibition, for the Gulf Market from 17th to 20th October 2000, at Bahrain International Exhibition Centre. The interested parties may directly contact the organizer on the following address for further information:
Al Madina Exhibition WLL, P.O.Box 26442, Adliya, Manama, Bahrain.
Fax: (+973) 310900
Email: madina1@batelco.com.bh
http://www.almadinaexhibition.com

FINE FOOD '2000, 17-20 NOVEMBER, 2000

Contact: Austrailian Exhibition Service Pty. Ltd. ACN 006 002

286, Illoura Plaza, 424 St. Klda Road, Milbourne VIC 3004,
Tel: 03 9261 4500
Fax: 03 9261 4545
Email: food@ausexhibit.com.au
www.usexhibit.com.au/supermarket

2000 BUSINESS OPPORTUNITY FOR THE NEW MILLENIUM
Contact: Consulate General of the Republic of Indonesia E/1-5, Shahrah-e-Iran, Clifton, Karachi.
Fax: 5874483

(Courtesy: RCCI News Bulletin No. 7/ 2000 dated 1st April, 2000)

HUMAN RESOURCES MIDDLE EAST, BAHRAIN, 9-12 OCTOBER, 2000
Contact: Montgomer Exhibitions Ltd., 11 Manchester Square, London, United Kingdom WIN 5AB.
Tel: +44 171 886 1951, +44 171 862 2041
Fax: + 44 171 486 8773, +44 171 862 2049
Email: hrme@montnet.com

BLIND AND SHUTTERS '2000, THELFORD 8-10 OCTOBER, 2000
Contact: British Blind & Shutter Association, 42 Health Street, Tamworth, Staffordshire, United Kingdom
B79 7JH
Tel: 1827 52337
Fax: +44 1827 310827

CENTRAL EUROPEAN COATINGS SHOW, KATOWICE, POLAND 7-9 NOVEMBER, 2000
Contact: DMG Business Media Ltd., Queensway House, 2., Queensway, Redhill, Surrey, United Kingdom RH1 1QS.
Tel: +44 1737 768611
Fax: +44 1737 855474
Email: tickets@dmg.co.uk

EURO-BLECH '2000, HANNOVER, GERMANY 5-9 DECEMBER 2000
Contact: Mack-Brooks Exhibitions Ltd., Forum Place, Hatfield, Hertfordshire, United Kingdom AL 10 ORN
Tel: +44 1707 275641
Fax: +44 1707 275544

SASMEX INTERNATIONAL '2000 (SAFETY AT SEA & MARINE ELECTRONICS EXH.)
Contact: DMG Business Media Ltd., Queensway House, 2 Queensway, Redhill, Surrey United Kingdom RH1 1QS
Tel: +44 1737 768611/855294
Fax: +44 1737 855474
Email: giones@dmg.co.uk
Website: http://www.dmg.co.uk

FURNITURE TECHNOLOGIES CONFERENCE '2000,OXFORD, 24-27 SEPTEMBER, 2000
Fira (Furniture Industry Research Associatin), Maxwell Road, Stevenage, Hertfordshire, United Kingdom SG1 2EW.
Tel: +441438 777640
Fax: +44 1438 777800
Email: pbeele@fira.co.uk

(Courtesy: RCCI News Bulletin No. 3/ 2000 dated 1st February, 2000)

BOOK REVIEW

“The Terminology Papers” (on the New Terms of Science and Technology), by Dr. Attash Durrani. Published by the Oriental Society for Knowledge,Islamabad, 1999, pp.223.Price Rs. 200/- ISBN: 969-8216-02-2

Science-terminology science is a new field, there is a dearth of authentic publications in this field. The author has claimed this publication to be the first book in the field of “Terminology Science” published in Pakistan. Dr. Durrani’s book is a welcome publication, especially for readers having interest in Urdu terminology.

The purpose of this publication is to provide basic source-material for the students working in.the field of translation and terminology. It is a collection of papers published by some renowned scholars in the field of terminology-science. The first three chapters are written by the author, Dr. Attash Durrani. Chapter 3 is based on the abstract of doctoral dissertation of Dr. Durrani, entitled “Urdu Terminology”. The remaining 19 chapters are based on the papers written by other scholars. Although the standard of these papers is high, some of these are highly technical and only advanced students in terminology-science will be in a position to benefit from these.

Dr. Durrani has mentioned the names of some of the earlier scholars in the subcontinent who had written papers on the development of Urdu terminology and the problems encountered in the implementation of standardized terminology. Some of the pioneers who made significant contributions are Moulvi Abdul Haq, Major Aftab Hassan, Syed Hussain Bilgrami, Dr. Shaukat Sabzwari, Rai Sohan Lal, Dr. Sved Abdullah and several others.

Tracing the history of Urdu terminology, Dr. Durrani has mentioned that the first dictionary of English-Hindustani terms was compiled by Thomas Roebuck, a teacher at Fort William College, Calcutta, in 1811. Since then, some 211 dictionaries and 419 indexes and glossaries were published by the year 1990. The standardization conferences and the preparation of principles for coining terms in Urdu began in 1840 in Delhi College, whereas the standardization work in English started much later, in 1867. The author has pointed out that the development of terminology has become a big challenge. As new branches of’ science and technology emerge, the West is expanding its terminological vocabulary at a rapid pace. It has been estimated that more than 25 terms are being added daily to the existing one million terms. No language can possibly cope with the gigantic task of translating all the terms completely. The task of the experts in Eastern languages is even more difficult. Apart from other difficulties, the impossibility of transliterating makes it difficult to convey the exact meaning that was originally meant when a certain technical torn was coined with a “different language-culture” behind it. At times, grammar does not permit the inclusion of foreign mode of expression, which the term conveys. An alternative approach to this is “transnationalization of terms”, through taking Latin and Greek morpheme roots and making our own derivatives, according to our own system and grammar.

The problems of differences in syntax, phonetics and in writing-systems will need to be resolved; the other new challenge is the changing and mutating of terms. If one accepts internationalism or transnationalism to some degree, even then it is *not* possible to keep pace with rapid changes in the meanings and concepts of words and terms in various fields. A student who graduated earlier, say ten to fifteen years ago, may find himself ignorant of the new words coined for the same concepts he knew or for the new concepts of the same term he had used before.

The author has discussed the different trends and approaches in the making of Urdu terminology. The school of puritans consider Urdu as strong as other academic languages. They recommend retaining previous words in terminology derived from sources in Arabic, Persian, Sanskrit, etc. Maulvi Waheed-ud-Din Saleem and Ch. Barkat Ali, amongst the earliest scholars of terminology, belong to this school. Then there are other scholars who recommend rejection of previous terminology-terms and internationalization through adoption of English and Western terminologies The author has quoted opinions of some eminent scholars on this subject. Prof. Abdus Salam, Nobel Laureate, had recommended: “We have to invent an Urdu, in which international science should remain international and Urdu as a better Urdu". The late Major Aftab Hassan, Secretary, Scientific Society of Pakistan, and enthusiastic advocate of Urdu terminology, had suggested:

i) The names of chemicals should *not* be changed,
ii) Latin names of order, genus and species of plants and animals should *be retained* as such,
iii) Pharmaceutical and generic names of drugs should *not* be changed.

Zygmut Stoberski from the World Bank of International Terms (WBIT), Warsaw, has also recommended internationalization of terminology.

Dr. Durrani has made the following recommendations in his doctoral dissertation:

> i) Modern science of terminology should be introduced in the making and teaching of Urdu terminology.
> ii) An electic approach with hybrid terms should be used.
> iii) A comprehensive collection of all Urdu terminology should be compiled, merged and published with the assistance of comptuers. This would comprise more than 250,000 terms.
> iv) New work in this field should be launched with the help of international orgnaizations, such as Eurodicautom, WBIT, IOUTN, Term Net, etc.

The author has done a creditable job of bringing under focus relevant issues in development of terminology, with special emphasis on Urdu terminology in the field of science and technology. He is eminently well qualified to undertake this task, having done his doctorate in Urdu terminology, and possessing broad experience as head of Bureau of Translation, Dictionaries and Terminologies, National Language. Authority, Islamabad.

Inspite of many praiseworthy aspects of this publication, there are a number of short-comings, which undermine its usefulness to the readers. The ad-hoc arrangement of 22 chapters of the book, ignoring the logical sequence, has made it difficult for the lay reader to grasp the essential elements and the dimensions of the field of terminology. Chapter 6, which deals with the basic issues, such as "what is terminology", "why is terminology so important", etc., should have come at the beginning of the book, so as to familiarize the reader with the basic concepts. The purpose of this publication, as stated by the author, is to provide basic reading-material for the students of translation and terminology. This objective can not be achieved easily due to the scattered nature of the basic information required by the students and scholars of technology-science. The problem is further aggravated by the absence of a glossary of terms and acronyms, for quick reference by the reader. A glossary of technical terms, such as, internationalization, transnationalization, terminology, neologism, etc., could have saved valuable time of the reader in searching through the book for a definition of these terms. Similarly, the glossary could have provided quick reference to the acronyms used in the book, such as, INFOTERM, WBIT, IOUTN, COTSWE, etc.

The book has been burdened with unnecessary personal data of the author on p.19 which is not relevant to the topics being discussed. The author has mentioned the details of his doctoral dissertation, its duration, name of his major professor alongwith the names of some other persons who proivded him with literature related to his field of study. Since complete information about the author is given in his curriculum vitae on the last page of the book, as well as on the back cover, the information given on page 19 is a mere repetition.

Frequent typographical errors, coupled with ambiguity of ideas in the first three chapters, makes it difficutl to understand what the author wishes to convey to the readers. This may be seen from the following quotation from pp. 12 & 13:

"If as a result of over emphasis on brevity, Terminology turns educated persons into illiterate, every quarter-century, humanity will end up by making no progress at all.... The International Media working towards One World-Language of One World-Order is working towards into own destruction. The illiterates of future generations will rise to finish the Literates of Neologism. It is astonishing that the Muslim intellectuals have not yet reacted to this challenge. The media of Muslim lands is making the mistake of falling into the trap by offering science and technology through the seemingly literated mental attitude of Internationalism. Those who point out the pitfall are termed fundamentalists and uncultured retrogrades.....We need to make aware our media so that, as an Ummah, we do not fall into the trap of turning us into the chaos of Science and Technology through accepting International Terminology".

There appears to be some contradiction in the views expressed above with those stated in later chapters, where the author says: "Mr. Stoberski has very rightly said in his paper on Theory and Practice of Internationalization of Terminology, and we are of his opinion for Urdu also, that if we will not internationalize our language, we will hinder our development". Furthermore, the author has grouped the problems of terminology-development for the Muslim Ummah as a whole, ignoring the fact that the Muslim countries have a diversity of languages, differing in script, grammar and syntax. The problems of terminology-development in the Arab countries, Russian Republics (C.I.S.), South Asian Countries and the Far East are different according to the language spoken and taught in their educational system. They have different policies in respect of the adoption of national language for transaction of official business.

An appropriate revision in the 2nd edition would make this monograph much more usefu to the intelligent reader.

Dr. S.M. Jaffar
Retd. Senior Scientific Adviser,
Ministry of Science & Technology
Islamabad

FLASH BACK WELCOME

In future issues of SCIENCE VISION it is intended to present:

* Future Plan
* Industrial Opportunities:
  i) Resources Sought
  ii) Technology offered
* Consultants wanted
* Review Articles
* Scientific & Technology Research Articles

The Editor would appreciate receiving:

* Queries
* Comments
* Suggestions
* Criticism

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