CONTENTS OF HEAVY-METALS IN WATERS OF NULLAHS DEK, BISHARAT & AIK, AND THEIR EFFECT ON SOIL-HEALTH

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ABSTRACT

A Survey was conducted on different Nullahs receiving city and industrial effluents contaminated by different heavy metals during July, 2002. This water is used for growing crops, particularly rice crop. Three Nullahs, namely Dek, Bisharat (locally called Dek) and Aik were surveyed; soil and water samples were collected from different spots/sites for determination of their quality (chemical, nutritional characteristics and heavy metals contents). Nullah Dek is one of the three Nullahs surveyed, which enters Pakistan near Pasroor, passes through Sialkot, and Sheikhupura districts. From this Nullah water-samples were collected from 5 sites i.e. Typiala Dost Mohammad on Muridke Narowal road near Narang Mandi, Shamke near Kala Shah Kaku, Shakirabad railway station and Village on Lahore - Faisalabad railway track, Lahore Sheikhupura road near Madina town, Thatta Wasiran, a village in District Sheikhupura and Galo-Tian where the Nullah enters into upper chenab canal (UCC). Water- samples from Nullah Bisharat were also collected from three sites i.e. near Allo Dhar, Villages near Lahore Gujranwala road, Lahore- Sheikhupura road near Kallah and Sheikhupura Muridke road near Servis Industry, Muridke (Industrial area). In case of Nullah Aik, only one water sample was collected near Sialkot city when it has collected the city sewerage of Sialkot. Seven sites were selected on the bank of this Nullah namely i) Typiala Dost Muhammad, ii) Shamke iii) Missan Kalar iv) Kot Pindi Das, v) Shakirabad a village and a Flag railway station, and vi) Thatta Wasiran (Two sites 1 & 2).

A total of forty soil-samples were taken from all these sites from 0-15 cm and 15-30 cm depths. All the soil-samples were brought to the Laboratory, air-dried, ground and passed through a 2 mm sieve, and analysed for chemical characteristics, including nutritional status and heavy-metals contents. All the ten water-samples were also analysed for quality-characteristics and heavy-metals contents. The results showed that Nullah Dek water near Typiala Dost Muhammad is free from excess of soluble salts and sodicity hazards; even heavy metals are absent except Mn (0.1) and Cd (0.001), which are within safe limits. But in the same nullah when it passes through Muridke industrial area, the total salts concentration is higher than the safe limit (>1 EC dSm^{-1}). Even SAR is high, particularly at Shamke and Shakirabad, but it has no problem of high RSC. Among heavy metals, Zn, Mn, Cd and Sr are present at all the places, but these are within safe limit, except Sr. In case of Nullah Bisharat, total salts concentration is very high at all the places and it also has sodicity hazard (high SAR), but no problem of high RSC, except at Allo Dhar. Among heavy metals Zn, Mn, Cd, Sr were present at all the places, but within safe limits. The water of Nullah Aik has EC (total salt concentration) within safe limit and contains Zn, Mn, Ni, Cd and Sr, but all within safe limit, except Sr.

In case of soil-samples the data showed that all these samples were free of salinity/sodicity hazards, except a few, which had EC_e more than 4 and only one sample which has SAR more than 15. All these samples were deficient in 0.M (>1.29 % sufficient level), deficient to medium in available phosphorus and medium to sufficient in extractable K. Among heavy metals, the Zinc ranged between deficiency limit (<0.5 mg Kg^{-1}) to adequate amount (>1.0 mg Kg^{-1}) at different locations; Copper, Mn and Fe were present in adequate amounts at all the sampled sites. Nickel and cadmium were within safe limits, whereas Strontium was in excessive amounts.

INTRODUCTION

Pollution of environment is an undesirable change in the physical, chemical and biological characteristics of air, water and soil, due to the addition of material or energy to the environment in quantities and at a rate which is harmful to living organisms, including human beings (2, 19). It is also described as: a substance or effect is normally considered to be pollutant if it adversely alters the environment by changing the growth-rate of species, interferes with the food-chain, is toxic or interferes with health, comfort, amenities or property values of the people (29). A pollutant is a substance or effect that is introduced into the

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Table - A: Critical levels of heavy-metals in polluted water

Parameter	Unit	Critical Levels
pH	-	-
EC	dS m^{-1}	1.50*
RSC	mmol L^{-1}	2.25*
SAR	"	10.0*
Cadmium	mg L^{-1}	0.01**
Copper	"	0.20**
Iron	"	5.00**
Lead	"	5.00**
Manganese	"	0.20**
Nickel	"	0.20**
Zinc	"	2.00**
Strontium	"	-
Note: * U. S. Salinity Laboratory Staff (1954)		
** Recommended maximum concentration in irrigation w ater (Ayers and Westcot, 1985)		

environment in a significant amount as sewage-water, accidental discharge or as a by-product of manufacturing process or other human activity. The land we walk on, the air we breathe and the water we drink are slowly being polluted in the process of our struggle for better living. Industrial effluents/ emissions are the major sources of pollution (34). Sometimes accidental discharge of these effluents in large quantity can cause acute poisoning of the surrounding areas, resulting in large death-tolls. In low-dose exposure, the death may not be instantaneous, but still it can cause major damage to human health (16). A report by ILO (12) reveals that most of the studies on the problem of industrial pollution have been conducted in the developed countries and very few in developing countries. But this does not mean that the problems of pollution and health-hazards do not exist in the developing countries.

In Pakistan there is only 199 billion cubic meter water available (1), which is not sufficient to meet the water-requirements of the crops. The urban agricultural soils of the country are often irrigated with city-effluents for growing of vegetables (13, 25). Farmers use it as a source of irrigation and nutrients (10), while the administrators consider it a viable practice for disposal.

Rice is an important cash-crop of Pakistan. Its water-requirement, which is more than any other crop, is estimated as five-acre feet for one season. However, due to shortage of canal irrigation-water, the farmers use under-ground as well as surface water. The main rice-growing area, named as Kallar tract, consists of the districts of Sialkot, Gujranwala, Hafizabad, parts of Lahore, Qasur and Sheikhupua. A number of nullahs starting from Kashmir pass through this area, nullahs Aik, Dek, Palkhu and Basantar being the most famous. These nullahs pass through the biggest industrial zone of Punjab i.e. G.T. road industrial area. While passing through this zone, they pick up the industrial effluents and the human wastes, because the city-sewage drains from Sialkot and Gujranwala along with many small towns, fall into these nullahs. In rainy seasons, these nullahs inundate the surrounding cropped area. Moreover, the farmers lift this polluted water to irrigate rice-fields, through pumps installed along their sides. The practice is well known throughout the last century; however, with the increase of population and development of industrial zone in the area, it has turned into a menace. Since the use of such effluents as irrigation-water may introduce some metal ions, which may accumulate in the plants, the practice may be a potential hazard. The metal ions can induce toxic impact on the living systems, if present in excessive concentrations (22, 23, 31). The heavy metals accumulate in the plant-material grown in these soils, which will ultimately go to the human body through food-chain, directly, or indirectly causing a number of physio-mental problems (28) Zakiullah et al. (35) collected fifty water-samples from Soan during the months of July, September and November of 1994 and January and March of 1995.

Table - B: Critical levels of different metal ions in Soil

Metal ion	Low	Medium	Adequate (mg Kg^{-1})
Zn	<0.5	0.5-1.0	>1.0 **(DPTA)******
Cu	<0.2	-	>2.0 **(DPTA)******
Fe	<4.5	-	>4.5 **(DPTA)******
Mn	<1.0	1.0-2.0	>2.0 **(DPTA)******
	Total		**Available (mg Kg^{-1})**
Cd	0.50*		0.31** **(AB-DPTA)**
Ni	25.0*		8.10** **(AB-DPTA)**
Pb	50.0*		13.0** **(AB-DPTA)**

Note: * Rowell (1994)

** MacLean et al. (1987)

*** Soltanpour (1985)

**** (Lindsay and Norvell, 1978)

They reported the mean pH ranged from 6.44 to 7.27, Cd 0.72-1.46, Cu 0.68-1.43, Ni 1.31-2.81 and Pb 0.77-1.65 mg l^{-1}. All the four heavy metals were above the toxicity limits (Cd 0.5, Cu 1.0, Ni 1.0, Pb 0.5 mg l^{-1}) set by National Environmental Quality Standards (3, 25) for irrigating crops or for human consumption (see Table-B).

Heavy metals are those inorganic nutrients having a density of greater than 6 Mg m^{-3} (7).The concentration of individual metals in living tissues is ordinarily very low. Some heavy metals are essential in low amounts, namely Co, Cu, Fe, Mn, Mo and Zn for plants; Cr, Ni and Sr for animals while Cd, Hg and Pb have not been established to be essential for either plants or animals (20). There is great concern that several toxic elements are accumulating in soils, as a consequence of industrial and urban activities and, or because of, the use of untreated sewage-sludge (7). The sewage-effluents are considered not only a rich source of organic matter and many other plant-food nutrients (14) but also contain heavy metals like Fe, Mn, Cu, Zn, Pb, Cr and Ni. However, continuous use of such effluents for crop-production could result in accumulation of such metals in concentrations that may become phytotoxic (11, 15).

Narwal et al. (21) studied the Nickel enriched sewage-water effect on accumulation of metals by corn grown in soil-1 (sandy, pH_s 8.0, EC_e 3.2 d S m^{-1}, organic carbon 0.17%, CEC 4.3 c mol kg^{-1}, diethylene triamine penta acetic acid (DTPA) extractable Zn 0.8, Mn 5.7, Fe 3.2, Cu 0.9 mg Kg^{-1}); the total Ni extracted by 4N HNO_3 was 17.3 mg Kg^{-1}; soil-2 (sandy, pH_s 7.8, EC_e 0.15 dSm^{-1}, organic carbon 0.14% CEC 3.4 c mol kg^{-1} DTPA extractable Zn, 0.2, Mn 3.6, Fe 1.8, Cu 0.3 and total Ni 12.3 mg Kg^{-1}); soil-3 (clay loam, pH_s 7.7, EC_e 1.08 dSm^{-1}, organic carbon 0.70 %, CEC 14.7c mol kg^{-1}, DTPA extractable Zn, 0.8, Mn 5.8, Fe 15.8, Cu 1.9 and total Ni 13.3 mg Kg^{-1}). They reported that plants supplied with 400 mg l^{-1} Ni died within a few days and root-biomass decreased. Concentration of Zn in root and shoot decreased with increasing Ni levels, i.e. antagonistic effect of Ni on the uptake of Zn by corn plants. The Mn concentration in shoots tended to increase at higher rates of Ni application. However, no definite relationship between Ni and Cu (plant vs soil) could be found. Iron concentration increased significantly from 108 to 471 mg Kg^{-1} in shoot and from 1761 to 2258 mg Kg^{-1} in root, with increasing Ni from 0 to 200 mg Kg^{-1} i.e. Ni has synergistic effects on Fe uptake by corn plants.

Bansal et al. (6) compared accumulation of Zn, Cu, Mn and Fe in soils irrigated with industrial waste-water and tubewell water. The sandy loam soil irrigated with industrial waste-water for 5 years originally had pH_s 7.6-8.5, organic carbon 0.06-0.71% and DTPA extractable Zn 0.7-47.0, Cu 0.8-26.0, Fe 9.2-60.6 and Mn 6.4-12 mg kg^{-1} soil; sandy loam soil irrigated with industrial waste water for 2 yeas, to start with it had pH_s 8.3-9.2, organic carbon 0.33-0.60% and DTPA extractable Zn 0.5-1.70, Cu 0.1-2.3, Fe 6.5-24.0 and Mn 2.9-9.3 mg kg^{-1} soil and sandy loam soil irrigated with industrial waste water had pH_s 8.9-9.3, organic carbon 0.09-0.48% and DTPA extractable Zn 0.4-0.9, Cu 0.3-1.6, Fe 4.2-28.5, and Mn 2.2-3.2 mg kg^{-1} soil at the beginning. The DTPA extractable Zn, Cu, Mn,

Table - 1: Water Analysis Plan

Sr. No.	Location	Nullah	EC d Sm^{-1}	CO_3 me/ l	HCO_3 me/ l	Cl me/ l	Ca+Mg me/ l	Na me/ l	SAR $(m\ mol\ l^{-1})^{1/2}$	RSC me/ l	Zn mg/ l	Cu mg/ l	Fe mg/ l	Mn mg/ l	Ni mg/ l	Cd mg/ l
1	Shamke	Dek	17.58	Nil	6	195	77.8	98	15.7	Nil	0.3	0.1	Nil	0.8	0.01	0.003
2	Shakirabad	Dek	10.47	Nil	6	111	56	48.7	9.21	Nil	0.5	0	Nil	0.4	-	0.002
3	Lhr.-Shk. Road	Bisharat	4.24	Traces	12	34.5	16	26.4	9.33	Nil	0.6	0	Nil	0.4	-	0.001
4	Do	Dek	5.34	Nil	12	41.3	28	25.4	6.79	Nil	0.7	0	Nil	0.3	0.01	0.001
5	T.D. Muhammad	Dek	1.02	Traces	6	2.5	5	5.2	3.29	1	0.7	0	Nil	0.1	-	0.001
6	Thatta Wasiran	Dek	4.88	Nil	11	37.5	24.2	24.6	7.07	Nil	0.7	0.1	Nil	0.1	-	0.001
7	Allo/Dhar	Bisharat	3.82	Nil	13	28	6	32.2	18.61	7	0.7	0	Nil	0.1	0.01	0.001
8	Service Inds. Muridke	Bisharat	2.53	Nil	10	16	8	17.3	8.65	2	0.7	0	Nil	0.1	-	0.001
9	Sialkot	Aik	0.84	4	2	3	5	3.4	2.15	1	0.6	0	Nil	0.1	-	0.001
10	Galo-Tian	Dek	5.3	Nil	13	39.5	28	25	6.68	Nil	0.7	0	Nil	0.3	0.01	0.001

and Fe accumulated in the 15-cm soil layer was more than that in lower one and the extent of their accumulation depended on the amount of industrial waste water applied.

A study was reported on the impact of Madhuana drain water on soils and vegetables (9). It was concluded that waste-water discharged from different industrial works at Faisalabad was unfit for irrigating the crops, i.e. EC (5.4 d S m^{-1}), SAR (12.7 m mol $l^{-1})^{1/2}$ and RSC (11.0 me l^{-1}). In soils [pH_s 8.18-8.45, EC_e 4.95-5.72 dSm^{-1}), SAR 12.18-13.68 (m mol $^{-1})^{1/2}$, Total N 0.11-0.20%] under cultivation of cauliflower and spinach using sewage-water, heavy metals tended to accumulate (Fe, 37.06-198.30, Mn 13.8-73.55, Cu 2.16-14.00, Zn 40.94-123.85 and Pb 0.49-5.76 mg l^{-1}) which were beyond the critical levels. Only Pb and Ni concentrations were within permissible limits.

Ghafoor et al. (8) studied the soil and plant composition irrigated with Paharang-drain sewage-effluent at Faisalabad. It was found that effluents from all the factories (Chenab Fabrics, Nishat Textile Mills, Pak Food and Flour Mills) had higher concentration of solutes than that of the main drain at villages Marzipura [EC 3.36 dSm^{-1}. SAR 10.21 (m mol $l^{-1})^{1/2}$, RSC 10.73 me l^{-1})] and Uchkera [EC 2.88 dSm^{-1}, SAR 9.54 (m mol $l^{-1})^{1/2}$, RSC 10.05(m mol l^{-1})], though all were unfit for irrigation.

Qadir et al. (26) conducted an experiment regarding metal-ion contamination of vegetables and soils irrigated with city-effluent. Composite soil-samples were taken from three sites (Judgewala, Marzipura and Uchkera) at 0-15, 15-30, 30-60, 60-90 and 90-120 cm depths. Fields at these sites were sandy loam to clay loam in texture. On an average, soils under vegetable marrow and spinach had pH_s 8.39, EC_e 2.93 dSm^{-1} and SAR 14.1 (m mol $l^{-1})^{1/2}$ in the plough layer. Contamination of metals (AB-DTPA extractable) in soils under vegetable marrow and spinach were Cd 0-0.22, Cr 0.40-2.10 , Cu 1.12-2.44, Fe 1.90-3.57, Mn 0.34-1.11, Ni 0.13-0.26, Pb 0.08-1.68 and Zn 0.25-2.88 mg l^{-1} while in soils under brinjal and onion these were Cd 0-0.04, Cr 0, Cu 1.72-6.52, Fe 2.97-12.83, Mn 2.76-7.88, Ni 0.15-0.48, Pb 1.12-8.85 and Zn 0.41-6.37 mg l^{-1}. The city effluent had pH 6.3-7.7, EC 3.5-4.1 d S m^{-1}, RSC 5.0-7.0 me l^{-1}, SAR 12.1-12.6 (m mol $l^{-1})^{1/2}$ and Cd 0, Cr 0.31-0.80, Cu 0-0.02, Fe 1.62-1.81, Mn 0.20-0.23, Ni 0.04-0.05, Pb 0.04-0.10 and Zn 0.09-0.10 mg l^{-1}.

MATERIALS AND METHODS

A Survey was conducted during July, 2002 on different Nullahs receiving city and industrial effluents, which were contaminated by different heavy metals. This water is used for growing of crops, particularly rice crop. Three Nullahs namely Dek, Bisharat (locally called Dek) and Aik (Figure-1) were surveyed; soil and water samples were collected from different spots/ sites for determination of their quality (chemical, including nutritional characteristics and heavy metals contents). Nullah Dek is one of the three Nullahs surveyed, which enters into Pakistan near Pasroor, and pass through Sialkot, Narowal, and Sheikhupura districts. From this Nullah, water-samples were collected from 5 sites i.e. Typiala Dost Mohammad on Muridke Narowal road near Narang Mandi, Shamke near Kala Shah Kaku, Shakirabad 'a railway station and village on Lahore - Faisalabad railway track", Lahore Sheikhupura road near Madina town,Thatta wasiran 'a village in District Sheikhupura" and Galo-Tian where the Nullah enters into Upper Chenab Canal. Water samples from Nullah Bisharat were also collected from three sites i.e. near Allo Dhar, villages near Lahore-Gujranwala road, Lahore-Sheikhupura road near Kallah and Sheikhupura-Muridke road near Servis Industry, Muridke (Industrial area). In case of Nullah Aik only one water-sample was collected near Sialkot city when it had collected the city sewerage of Sialkot. Seven sites were selected on the bank of Nullah Dek, namely i) Typiala Dost Muhammad (8 samples), ii) Shamke (8 samples) iii) Missan Kalar(4 samples) iv) Kot Pindi Das (6 samples), v) Shakirabad, a village and a Flag railway station (6 samples) and vi) & vii) Thatta Wasiran two sites{ site 1(4 samples) & site 2 (4 samples)}. A total of forty soil-samples were taken from all these seven sites from 0-15 cm and 15-30 cm. All these soil-samples were brought to Laboratory, air dried, ground and passed through a 2 mm sieve and analysed for chemical characteristics, nutritional status and heavy-metals contents. All the ten water- samples were also analysed for pH, EC, SAR, RSC,soluble cations and anions (CO_3,HCO_3 ,Cl,Ca^{2+} +Mg^{2+} and Na) using the methods of hand book NO.60 (32). Heavy metals in polluted water were determined according to the methods of Association of Official Analytical Chemists (4). All the chemical

Table - 2: Soil Analysis

Sr.	Location	Depth (cm)	pH_s	Ec_e d Sm^{-1}	CO_3 me/l	HCO_3 me/l	Cl me/l	Ca+Mg me/l	Na me/l	SAR (m mol	O.M. %	Available p (mg Kg^{-1})	Ex. (mg Kg^{-1})	Zn mg Kg^{-1}	Cu mg Kg^{-1}	Fe mg Kg^{-1}	Mn mg Kg^{-1}	Ni mg Kg^{-1}	Cd mg Kg^{-1}	Sr mg Kg^{-1}
1	Shamke	0-15	7.7	4.88	Absent	0.05	21.2	22.4	26.4	7.88	0.43	5.2	118	1.4	1.4	42.4	16.2	0.06	0.004	4.2
2	Do	15-30	7.8	4.19	Absent	0.05	19.8	19	22.9	7.44	0.15	5	121	0.6	1.2	43.6	15.6	0.04	0.004	2.6
3	Do	0-15	7.9	4.59	Absent	0.1	18.7	20.6	25.3	7.88	0.64	5.4	126	1.6	1	42.8	17.6	0.08	0.004	4
4	Do	15-30	7.9	3.89	Absent	0.05	17.4	14.6	24.3	9	0.35	5.2	119	0.6	0.8	42.8	16.6	0.08	0.004	3.4
5	Do	0-15	7.8	4.16	Absent	0.05	19.2	19.8	21.8	6.92	0.55	5	117	1.2	0.8	42.6	15.8	0.08	0.008	3.8
6	Do	15-30	8	4.21	Absent	0.05	19	19.8	22.3	7.08	0.35	4.6	130	0.4	1	42.4	17	0.06	0.006	3.8
7	Do	0-15	7.8	4.8	Absent	0.05	20.4	23	25	7.37	0.58	5.4	131	1.4	0.8	40.8	17.4	0.04	0.004	4.4
8	Do	15-30	8	3.58	Absent	0.1	16.3	15.8	20	7.12	0.23	58.1	118	0.2	0.8	42.6	16.4	0.06	0.004	5
9	Kot Pindi Das	0-15	7.7	6.08	Absent	0.05	12.5	26.4	34	9.48	0.58	5.2	109	2.2	2.2	49.8	30.6	0.06	0.004	4.6
10	Do	15-30	7.9	4.72		0.05	13.2	17.2	30.4	10.24	0.26	4.4	116	0.6	1.4	48.6	26	0.04	0.004	6
11	Do	0-15	7.8	6.87	Absent	0.05	20.3	29	39.7	10.42	0.58	4.8	117	2.2	2.4	50.2	32	0.06	0.006	4.8
12	Do	15-30	7.9	4.75	Absent	0.1	16.7	29.6	27.9	8.91	0.26	4.4	121	1	1.8	48.8	28	0.08	0.006	5.8
13	Do	0-15	7.7	5.96	Absent	0.15	12.9	25	34.6	9.77	0.69	4.6	126	1.6	2	50	30	0.06	0.008	3.8
14	Do	15-30	8	3.96	Absent	0.1	8.2	15.6	24	8.6	0.2	4.2	127	0.4	1.2	47.6	20	0.08	0.004	6.6
15	Missan Kalar	0-15	7.8	4.75	Absent	0.05	9.35	22.4	25.1	7.49	0.17	5	129	0.4	0.2	44	15.8	0.04	0.004	3.2
16	Do	15-30	8	5.17	Absent	0.05	11.3	27	24.7	6.73	0.12	4.8	136	0.2	0.2	38.2	9.6	0.04	0.004	6
17	Do	0-15	8.1	4.54	Absent	0.05	7.65	11	34.4	14.64	0.12	5.1	116	0.6	0.4	42.6	17.8	0.08	0.008	4.8
18	Do	15-30	8.8	6.47	Absent	0.1	11.7	3.2	61.5	48.81	0.1	4.2	111	0.2	0.2	41.6	15.6	0.06	0.004	4.8
19	Shakir Abad	0-15	7.9	2.24	Absent	0.1	3.7	7.4	15	7.81	0.58	5.5	112	1.8	1.4	50.2	24	0.08	0.01	6
20	Do	15-30	8.3	2.28	Absent	0.1	3.5	3.8	19	13.77	0.49	5.2	104	0.8	1.2	49	22	0.06	0.008	6
21	Do	0-15	8	2.27	Absent	0.1	3.55	8	14.7	7.35	0.41	6.3	109	1	1.2	49.8	26	0.08	0.012	6
22	Do	15-30	8.2	2.11	Absent	0.1	3.2	5.2	15.9	9.88	0.14	5.8	118	0.8	1.2	49.4	26	0.08	0.016	7.6
23	Do	0-15	8.1	1.69	Absent	0.1	2.6	6	10.9	6.3	0.72	5.4	120	1	1.4	50	30	0.1	0.01	7
24	Do	15-30	8.1	1.79	Absent	0.75	2.7	5.4	12.5	7.62	0.41	4.2	131	0.8	1.2	49.4	28	0.08	0.014	6.8

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Sr.	Location	Depth (cm)	pH_s	Ec_e d Sm^{-1}	CO_3 me/l	HCO_3 me/l	Cl me/l	Ca+Mg me/l	Na me/l	SAR (m mol	O.M. %	(mg Kg^{-1})	Ex. (mg Kg^{-1})	Zn mg Kg^{-1}	Cu mg Kg^{-1}	Fe mg Kg^{-1}	Mn mg Kg^{-1}	Ni mg Kg^{-1}	Cd mg Kg^{-1}	Sr mg Kg^{-1}
25	T.D. Muham mad	0-15	7.4	0.96	Absent	0.2	0.2	4	5.6	3.97	0.87	5.2	140	0.6	1	50.4	19.2	0.04	0.012	3.8
26	Do	15-30	7.6	1.11	0.05	0.15	0.4	5	6.1	3.86	0.61	4.3	139	0.2	0.8	50.4	19	0.06	0.012	5
27	Do	0-15	7.3	1.1	0.05	0.15	0.3	4.6	6.4	4.21	0.72	5.4	111	0.6	0.8	50.2	17.6	0.06	0.008	4
28	Do	15-30	7.5	0.92	0.05	0.25	0.3	4.6	4.6	3.03	0.58	5.2	112	0.2	0.6	49.2	12.4	0.06	0.01	2.2
29	Do	0-15	7.4	0.86	0.05	0.15	0.25	3.4	5.2	4	0.72	4.4	130	0.4	0.8	50.4	15.8	0.06	0.008	3.8
30	Do	15-30	7.5	0.83	0.05	0.1	0.35	3.8	4.5	3.26	0.58	4	119	0.4	0.6	50	18.8	0.06	0.008	4
31	Do	0-15	7.4	0.96	0.05	0.1	0.3	4.6	5	3.29	0.72	4.7	131	0.4	0.6	50.4	15	0.1	0.012	4.8
32	Do	15-30	7.6	0.81	0.05	0.15	0.35	4.4	3.7	2.5	0.4	4.1	132	0.4	0.6	50.6	16.6	0.1	0.01	3.8
33	Thatta Wasiran Site-1	0-15	8.2	1.71	0.1	0.25	1	1.8	15.3	16.11	0.55	4.9	140	0.6	0.8	49.6	19.6	0.08	0.01	5.6
34	Do	15-30	8.5	2.6	Absent	0.05	0.25	4	22	15.6	0.29	4.2	136	0.2	0.6	47.8	20.6	0.08	0.01	5.8
35	Do	0-15	8.4	4.61	0.05	0.25	5.4	3.6	42.5	31.72	0.55	4.6	132	0.6	0.8	49.6	28	0.04	0.02	5.4
36	Do	15-30	9.2	4.2	Absent	0.05	0.45	4	38	26.95	0.27	4.4	119	0.4	0.6	45.4	19.4	0.06	0.01	3.6
37	Site-2	0-15	8.2	1.27	Absent	0.15	1.2	2.2	10.5	10	0.81	5.3	118	1	0.4	47.6	19.2	0.04	0.016	4.8
38	Do	15-30	8.5	1.89	Absent	0.15	1.9	2.8	16.1	13.64	0.43	4.9	119	0.2	0.4	45.6	18.2	0.08	0.01	5.6
39	Do	0-15	8	1.09	0.05	0.1	0.75	2.4	8.5	7.73	0.87	5.8	124	1.6	0.4	45.6	18.6	0.06	0.024	5.4
40	Do	15-30	8.1	1.19	Absent	0.15	0.85	2.4	9.5	8.64	0.61	4.1	126	0.8	0.4	46	19.2	0.04	0.02	4

analyses of soil were done according to the methods given in hand- book NO.60 (32), except available phosphorus by Watanabe and Olsen (33) . Heavy metals from soil samples were extracted by using DTPA extractant and determined by using atomic absorption spectrophotometer (24).

RESULTS AND DISCUSSIONS

(a) Chemical Characteristics of Soil-Samples

The soil samples analyses (Table-2) indicated that all the soil-samples have pHs between 7.4 to 8.5 and only two samples have pHs more than 8.5 i.e. one at Missan Kalar site and other at Thatta Wasiran site-1, indicating the presence of sodicity hazard at these two sampling spots at lower horizon i.e. 15-30 cm depth. Majority of the soil-sampling sites have EC_e less than 4 dS m^{-1} i.e. within fit range, but a few have more than 4 dS m^{-1} indicating the presence of salinity at Shamke, Kot Pindi Das, Missan Kalar sampling sites. The soils of Shakirabad, Typiala Dost Muhammad and Thatta Wasiran both sites were free from this hazard, except one sample of Thatta Wasiran which has EC_e < 4 dSm^{-1} at upper depth and pH > 8.5 at lower depth i. e. sodic in nature. Carbonates in the saturation extract were absent at all the sampling sites, except Typiala Dost Muhammad and one sample (0-15 cm) of Thatta Wasiran. Bicarbonates in saturation extract of soil samples ranged between 0.05 to 0.75 me l^{-1}, chloride between 0.20-21.20 me l^{-1}, $Ca^{2+}Mg^{2+}$ from 1.8 to 29.6 me l^{-1}, Sodium 3.7 to 39.7 me l^{-1}, sodium Adsorption ratio 2.5 to 48.81 (m mol $l^{-1})^{1/2}$.

These soil chemical characteristics indicate that, although the water of nullah Dek and Bisharat is being used for many years for irrigation at all these sampling sites, yet the soils are still free from salinity/sodicity hazards. Ghafoor et al. (8) also came up with similar results regarding chemical characteristics of soils while studying the soil and plant composition irrigated with Paharang drain sewage-effluents at Faisalabad.

(b) Nutritional Status

The soil analyses data (Table-2) showed that all the forty soil samples of seven sites were deficient in organic matter, deficient to medium in available phosphorus and medium to adequate in extractable K. These results lead us to conclude that the water of these two nullahs is not a rich source of organic matter and other plant nutrients, as reported by Ibrahim et al. (14), due to which these soils in spite of being irrigated by the polluted water of these nullahs are still deficient in macronutrients.

(c) Heavy-Metal Contents in Soil Samples

The soil analyses results (Table-2) showed that zinc concentration was variable at all the sampling sites. It was medium to high at Shamke and Shakirabad, low to high at Kot Pindi Das and Missan Kalar, low to medium at Thatta Wasiran and low at Typiala Dost Muhammad. Copper, iron, Manganese and strontium were in excess amount at all the sites, while Nickel and cadmium were in deficient range at all the sites. A number of workers have also reported similar results i.e. the continuous use of polluted effluents for crop-production could result in accumulation of heavy metals in concentration that may become phytotoxic (8,9,11,14,15).

(d) Water Chemical Characteristics

Water samples from three nullahs were taken and analysed for chemical characteristics and Heavy metals contents. The results (Table-1) indicate that water of nullah Dek have high EC at Shamke, Shakirabad, Lahore-Sheikhupura road near Madina Town area, Thatta Wasiran and Galotian, while it's EC was in marginal range at Typiala Dost Muhammad. In case of nullah Bisharat, it also has high EC at all sampling sites i.e. Lahore-Sheikhupura road near Kallah , Allo/Dhar and Servis industries area Muridke while the water of Aik nullah have EC within fit range near Sialkot city. This indicates that the industrial effluents thrown to these nullahs are brackish and have high EC, while soil-analysis indicates that there is no problem of salinity created by the use of these nullahs water. The reason might be that rice is grown in Monsoon season and, due to rainy water in these nullahs, the salts concentration is diluted, due to which soils are safe from this hazard. Carbonates were almost nil in the nullahs water except Aik, which have CO_3 more than 4 mel^{-1}. While Bicarbonates were present and ranged between 2.0 to 13.0 ml l^{-1}, Chloride ranged between 3.0 to 195.0 me l^{-1}, Ca^{2+} + Mg^{2+} 5.00 to 77.80 me l^{-1} while sodium ranged between 3.4 to 98.0 me l^{-1}. Sodium adsorption-ratio ranged from 2.15

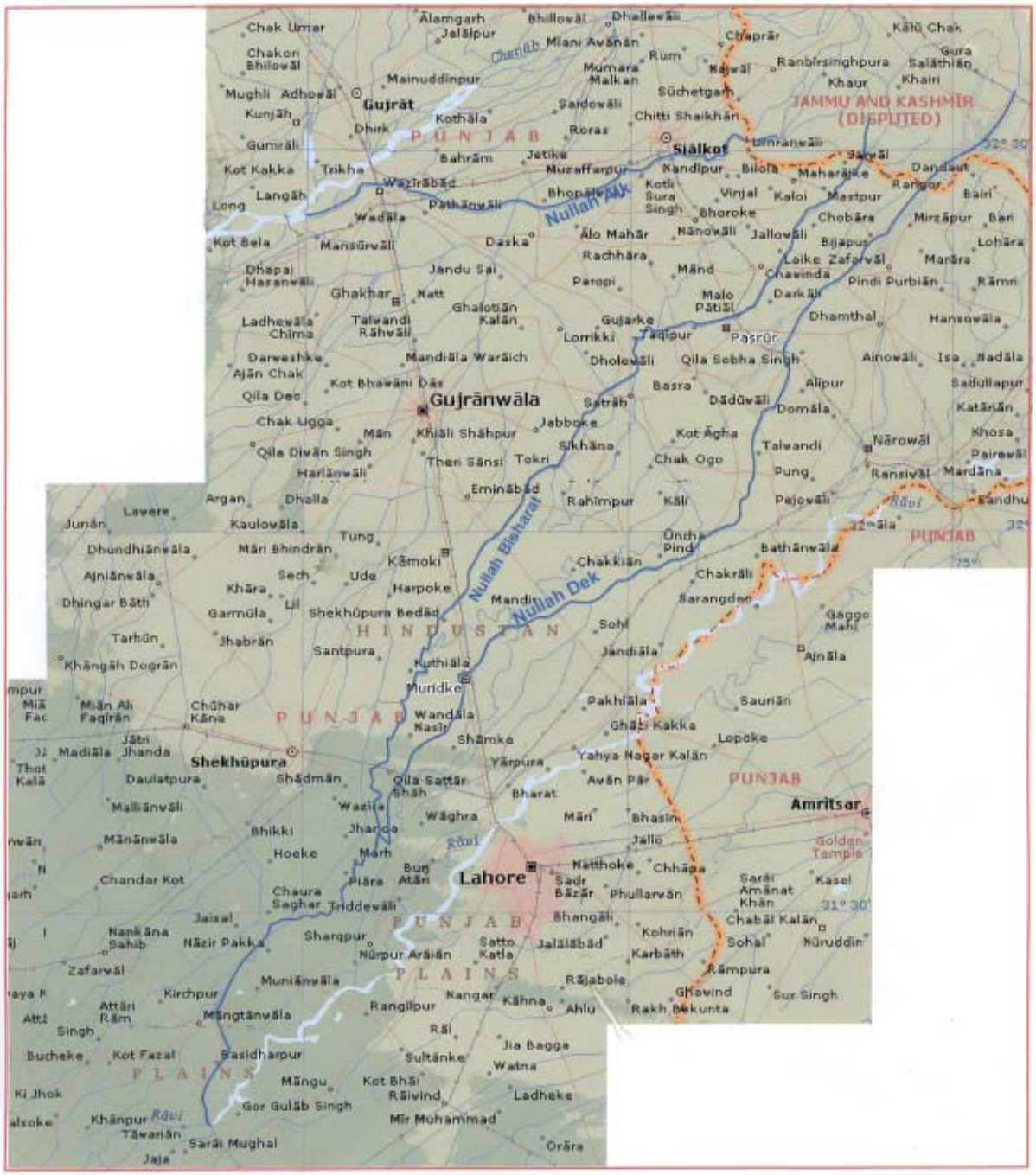

Figure - 1: Polluted NullahsTested for Heavy Metals

to 18.61, indicating that the water of Dek at Shamke, Shakirabad, Lahore- Sheikhupura road near Madina town, Thatta Wasiran, Galotian and water of nullah Bisharat at all the spots is sodic in nature. There was no problem of residual sodium carbonate at any sampling site of all the nullahs, except one place i.e. Allo Dhar (at nullah Bisharat) where it is more than the limit. Many Agricultural researchers also have reported that industrial effluents are highly brackish in nature (8, 25, 35).

(e) Heavy-Metals in Water

The water analysis data (Table-1) showed that Nullah Dek water near Typiala Dost Muhammad is free from heavy metals except Mn (0.1) and Cd (0.001) which are within safe limit. But the same Nullah when passes through Muridke industrial area, heavy metals, Zn, Mn,Cd and Sr are present at all the places, but these are within safe limit except Sr. In case of Nullah Bisharat, heavy metals Zn, Mn, Cd, Sr were present at all the places but within safe limit. The water of Nullah Aik contains Zn, Mn, Ni, Cd and Sr, but within safe limit except Sr. The farmers lift this polluted water to irrigate rice-fields through pumps installed along the sides in rice tract. The practice is being carried on for centuries; however, with the increase in population and development of industrial zone in the area, it has turned into a menace, since the use of such effluents as irrigation-water is introducing these metal ions, which may accumulate in the plants. The metal ions can induce toxic impact on the living systems, if present in excessive concentrations (22, 23, 31). The heavy metals accumulate in the plant-material grown in these soils, which will ultimately go to human body through food-chain, directly or indirectly causing a number of physio-mental problems (28). Ghafoor et al. (9) also studied the impact of Madhuana drain-water on soils and vegetables. It was concluded that waste-water discharged from different industrial works at Faisalabad was unfit, i.e. EC (5.4 d S m^{-1}), SAR (12.7 m mol $l^{-1})^{1/2}$ and RSC (11.0 me l^{-1}) for irrigating the crops. In soils [pH_s 8.18-8.45, EC_e 4.95-5.72 dSm^{-1}), SAR 12.18-13.68 (m mol $^{-1})^{1/2}$, Total N 0.11-0.20%] under cultivation of cauliflower and spinach using sewage-water, heavy metals tended to accumulate (Fe, 37.06-198.30, Mn 13.8-73.55, Cu 2.16-14.00, Zn 40.94-123.85 and Pb 0.49-5.76 mg l^{-1}) which were beyond the critical levels. Only Pb and Ni concentrations were within permissible limits. These high concentrations of metal ions in the nullah water are apparently due to the discharge of industrial effluents into these streams. The situation is alarming, especially in case of Strontium, which has very high concentration. The severity of the problem has increased manifold since the National Environment Quality Standards (3, 25) has not mentioned any limit on Strontium. The quality of Nullah water requires immediate imposition of stringent standard for strontium.

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LITERATURE CITED

1. Ahmad, N. 1993.Water resources of Pakistan. 61-B/2 Gulberg III, Lahore, Pakistan.
2. Ahmad, I. 1995. Ph.D.Thesis, QAU, Islamabad.
3. Anonymous, 1995.National environmental quality standards. A Survey Report, Govt. of NWFP, Pakistan.
4. AOAC. 1990. Official methods of analysis. Association of Official Analytical Chemists.AOAC Inc. Arlington, USA.
5. Ayers, R.S. and D.W. Westcot. 1985. FAO Irrig and Drain Paper 29, FAO, Rome, Italy. pp. 95-97.
6. Bansal, R.L., V.K.Nayyar and P.N.Takkar. 1992. J.Indian Soc.Soil Sci.40:796-799.
7. Davies, B.E.andL.H.P.Jones.1989.In: Wild A. (ed.).Soil conditions and plant growth (11th Ed.).Longman Group Burnt Mill, Harlow.UK.
8. Ghafoor,A.,A.Rauf and M. Arif. 1996. Pak.J.Agri.Sci.33:73-76
9. Ghafoor, A., A.Rauf and W.Muzaffar.1995. Drainage and Recl.7:7-12.
10. Ghafoor, A., A.Rauf, M.Arif and W.Muzaffar.1994. Pak.J.Agri.Sci.31:367-369.
11. Ghafoor, A., S.Ahmad, M.Qadir, S.I.Hussain and G.Murtaza.1999. J.Int. Agri.Biol.3:82-84.
12. ILO.1978.Technical Report Services NO. 601. Geneva, Switzerland.
13. Ibrahim. and S.Salmon.1992. J.Agri.Res.30:391-401.
14. Ibrahim, M., N Ahmad and S.A.Anwar.1998.Int. Seminar.In: Degraded Soils"process, management and analysis." Oct.19-24, 1998.Univ.Agri. Faisalabad, Pakistan.
15. Kirkham, M.B.1983. Agri.Ecosystem Environ.9:251-255.

16. Kozlowski, S.and P.Krasucki. 1979. Ergonomics. 22:651-659.
17. Lindsay, W.L., and W.A. Norvell. 1978. Soil Sci. Soc. Am. J. 42: 421-428.
18. MacLean, K.S., A.R. Robinson and H.M. MacConnell. 1987. Commun. Soil Sci. Plant Anal. 18: 1303-1316.
19. Mian, Z., T.Ahmad and A. Rashid. 1998. Pro. Int. Sym.on Agro-Environmental issues and future strategies towards 21st century. May 25-30, 1998.Univ.Agri. Faisalabad, Pakistan.
20. Misra, S.G. andD.Mani.1991.Ashish Publishing House, 8/81, Punjab Bagh, New Delhi, India.
21. Narwal, R.P., M.Singh and J.P.Singh.1991. J. Indian Soc.Soil Sci.39:123-128.
22. Nriago, J.O.1990. Environment, 32:7-33.
23. Nriago, J. O. and Pacyna. 1988.. Nature. 333: 134-139.
24. Page, A.L., R. H. Miller and D.R. Keeny. 1982. Agron. 9, SSSA. Madison, WI, USA.
25. Qadir, M., A. Ghafoor., G. Murtaza and S. Farid. 1998. In: Proc. Inter. Sym. On Agro-Environmental issues and future strategies towards 21st century. May 25-30, Univ. Agric., Faisalabad, Pakistan.
26. Qadir, M., A. Ghafoor, S.I. Hussain, G. Murtaza and T. Mahmood. 1997. In Proc.Environmental Pollution: Third Ntl.Symp. Modern Trends in Contemporary Chemistry. 24-26 February,1997, Islamabad, Pakistan..
27. Rowell, D.L. 1994. Pesticides and Metals p 303-327. In : Soil Science: Methods and applications. Longman Singapore Publisher Ltd. Singapore.
28. Sial, R.A. 2000. Ph.D. Thesis, Quaid-i-azam Univ. Islamabad, Pakistan.
29. Singh, R., R. V. Singh and A. K. Shukla. 1991. Yield and heavy metal contents of berseem as influenced by sewage water and refinery effluent. J. Indian Soc. Soil Sci. 39: 402-404.
30. Soltanpour, P.N. 1985. Use of AB-DTPA soil test to evaluate elemental availability and toxicity. Commun. Soil Sci. Plant Anal. 16: 323-338.
31. Tiller, K. G. 1989. Heavy metals in soils and their environmental significance. Adv. Soil Science. 9: 113-142.
32. U.S.Salinity Lab.Staff.1954.Diagnosis and improvement of saline and alkali soils. U.S.D.A. Hand Book No. 60. pp. 160. Washington, D.C.
33. Watanabe, F.S. And S.L.Olsen.1965.Test of an ascorbic acid method for determining P in water and $NaHCO_3$ extract fromSoil.Soil Sci. Soc. Am. Proc., 29:577-578.
34. WHO.1977.A report on working conditions and life. Bangkok, Thailand.
35. Zakiullah, M., T.Ahmad and A. Rashid. 1998. Accumulation of heavy metals in water of river Soan due to effluents in industrial area.p.1-4.In:Proc.Int.Sym.on Agro-Environmental issues and future strategies towards 21st century. May 25-30, Univ.Agri. Faisalabad, Pakistan.