Pollution of Phulali Canal Water in the City Premises of Hyderabad: Metal Monitoring

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Summary: Phulali canal passes through Hyderabad city with a population of about 2 million. Most of the municipal and city industrial effluent is added to canal water during an area of 14 km and has direct impact on the health of human beings, crops and cattle life. The levels of trace and toxic elements are found higher in the order > Mg (249.53 mg/l) > Ca (83.446 mg/l) > Na (45.778 mg/l) > K (11.697 mg/l) > Al (1.592 mg/l) > Fe (1.451mg/l) > Mn (0.596 mg/l) > Ba (0.576 mg/l) > Zn (0.167 mg/l) > Co (0.151 mg/l) > Cr (0.0082 mg/l) > Pb (0.026 mg/l) > Cu (0.063 mg/l) > Cd (0.004 mg/l) > Ni (0.005 mg/l). Strong positive correlation also exists for certain pair of elements like Mg-Cu (r = 0.963), Na-Ni (r = 0.932), Ba-Zn (r = 0.929), Al-Mn (r = 0.829), Ca-Ni (r = 0.811), Mn-Fe (r = 0.757), Ni-Mn (r = 0.699), Cu-Cr (r = 0.533), K-Ca (r = 0.491), Cd-Ba (r = 0.448), Cr-Co (r = 0.366), Pd-Cu (r = 0.238), Zn-Fe (r = 0.212) and Fe-Co (r = 0.154). The results have been compared with NEQs, drinking water upper limits for human beings and livestock, irrigation water limits and aquatic life protection limits. The levels of manganese, iron and cobalt are found higher than the irrigation water restriction values and overall water is poorly unsuitable for drinking of livestock, aquatic life and for irrigation purposes in the long run.

Introduction

In Pakistan, most of the industries discharge untreated effluent into the public sewer system, which also carries the domestic wastewater [1, 2]. This blended water is ultimately disposed into rivers, which provide irrigation water to about 78 percent of the cropped land. The use of untreated wastewater effluent for irrigation has many serious threats to cultivated crops and for the health of growers. Environmental pollution caused by disposing the wastewater effluent into the drainage and irrigation network may also create soil fertility problems [3, 4].

As there is practically no check to use these effluents for irrigation and thus in this scenario, heavy metals reach the arable lands for that trickles down, violating the hydraulic environment pertinent to the crop badly and this practice is going on for the last several decades [5]. In small quantities, many elements are essential for plant growth but their high concentration leave negative effects by causing toxicity to plants and animals [6, 7]. In wastewater effluent the high concentration of heavy metals is considered harmful for those plants, which utilizes this water and texture of soils. The major source of heavy metals in municipal wastewater is that effluent coming out from industrial processing [8]. Studies show that natural water pollution has consistently increased with industrialization and urbanization [9-11].

Nonperennial Phulali canal was constructed in 1955 to meet the irrigation requirements of the locality. The canal originates from left bank of river Indus from Ghulam Muhammad Barrage and has the discharge capacity of 14350 cusecs with total cultureable commanded area (CCA) of 929358 acres [3]. The canal passes through Hyderabad city with a population of about 2 million. The water of the canal is used mainly for agriculture purposes and also for drinking of human beings in rural Sindh and domestic animals. This effected irrigation water of the canal deteriorates the quality of irrigated crops [3, 4].

In a city like Hyderabad there has been rapid industrial development along with congestion of urban areas, which has been responsible for corresponding deterioration of the environment [4].

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Many areas of the city where canal passes through, industrial activities dump their wastewater along with their sewerage into this canal and cause pollution of the canal water. The other sources of pollution in this canal water are animal faeces and domestic garbage. Some congested housing colonies and kachi abadies are also disposing off their wastes into the Phulali canal water [12–14]. This pollution might influence the yield of crops through deteriorating soil chemical and physical properties especially soil hydraulic conductivity and soil water-holding capacity [15–19].

The average quantity of wastewater (Table 1) discharged into Phulali canal from different sewage stations is 225584.44 m^3/day. These large volumes of organic and inorganic substances change the chemical characteristics of the water body by producing toxic substances and ultimately pollute the canal's water [12]. The use of polluted waters has been reported to have adverse effects on livestock and vegetation [20].

Table-1. *Average quantity of wastewater and the % contribution of wastewater from different sewage stations discharged into Phulali canal.

Waste water station	*Average quantity discharged m^3/day	% Contribution of the total discharged
Jacob tank Cantonment board waste	13944 ± 1397	6.18
Kali Mori open drain	56376 ± 2232	25
Open drain near old power house	42323.44 ± 3229.82	18.76
Darya Khan panhwer pmping station	96441 ± 4151	42.75
Site area pumping station near Nara Jail	13500 ± 1963.4	5.98
Other sources	3000 ± 855	1.33
Total	225584.44	100

*Reproduced from ref. 12 page 360

Trace elements are of concern for irrigation or animal drinking water use. The nutrients found in reclaimed water occurring in permissible quantities are important to agriculture and landscape management. Municipal wastewaters usually contain sufficient amounts of micronutrients to prevent deficiencies. The trace elements of B, Cu, Fe, Mn, Mo, Zn, Na, and Cl are essential for plant growth; however, intake of excessive concentration of these elements can be toxic and detrimental to some plants. Certain recommended limits for constituents in reclaimed water for irrigation have been shown in Table 2 for comparisons [21].

Parameters like pH, EC, COD, DO, BOD, Fecal coliforms and SAR have already been reported elsewhere [3]. The present work describes the monitoring of some essential, trace and toxic elements like sodium, calcium, magnesium, potassium, lead, cadmium, copper, nickel, aluminium, barium, zinc, manganese, chromium, iron and cobalt and their impact on the quality of irrigation water due to combined industrial and municipal discharge effluents in the canal water is also discussed.

Results and Discussion

The water bodies like streams, canals, rivers and oceans have their own system of keeping themselves clean but the untreated wastewater from our cities is reaching above the threshold of these water sources to clean automatically. After contamination of water, aquatic life like fish and plants etc. become extinct. In the winter season the importance of wastewater becomes more acute as the quantity of this canal water is reduced. This leads to reduction of oxygen in the water and fish cannot survive. If this contaminated water is used for drinking purposes, it causes many diseases especially those related with the digestive system [6, 22]. Table 3 shows levels of fifteen trace and toxic elements studied under present research for monitoring of Phulali canal water.

Table-3 shows that the extra amount of calcium i.e. 83.446 mg/l may be because of regular mixing of municipal sewage. Calcium is an essential plant nutrient and waters high in calcium or magnesium are considered hard and are not desirable for domestic water supplies, but hard water is considered good for irrigation. Calcium helps to keep soils in good physical condition, which favors good water penetration and easy tilling. [11, 12, 16–18].

Higher amount of magnesium 249.53 mg/l (Table-3) exceeds NEQs and drinking water restriction limits and may cause serious effect on soil, which is irrigated with this water. Magnesium is another essential plant nutrient and normally occurs at about half the concentration of calcium. Crops grown on soils having an imbalance of calcium and magnesium may also exhibit toxic symptoms [19, 23, 24].

Maximum load of sodium is observed at point 2. Increase of sodium *i.e.* 45.778 mg/l, may increase

Table 2. *Recommended limits for constituents in reclaimed water for irrigation.

Constituent	Long-term use (mg/L)	Short-term use (mg/L)	Remarks
Aluminum (Al)	5.0	20	Can cause nonproductivity in acid soils, but soils at pH 5.5 to 8.0 will precipitate the ion and eliminate toxicity.
Arsenic (As)	0.10	2.0	Toxicity to plants varies widely, ranging from 12 mg/L for Sudan grass to less than 0.05 mg/L for rice.
Beryllium (Be)	0.10	0.5	Toxicity to plants varies widely, ranging from 5 mg/L for kale to 0.5 mg/L for bush beans.
Boron (B)	0.75	2.0	Essential to plant growth, with optimum yields for many obtained at a few-tenths mg/L in nutrient solutions. Toxic to many sensitive plants (e.g., citrus) at 1 mg/L. Most grasses relatively tolerant at 2.0 to 10 mg/L.
Cadmium (Cd)	0.01	0.05	Toxic to beans, beets, and turnips at concentrations as low as 0.1 mg/L in nutrient solution. Conservative limits recommended.
Chromium (Cr)	0.1	1.0	Not generally recognized as essential growth element. Conservative limits recommended due to lack of knowledge on toxicity to plants.
Cobalt (Co)	0.05	5.0	Toxic to tomato plants at 0.1 mg/L in nutrient solution. Tends to be inactivated by neutral and alkaline soils.
Copper (Cu)	0.2	5.0	Toxic to a number of plants at 0.1 to 1.0 mg/L in nutrient solution.
Fluoride (F^-)	1.0	15.0	Inactivated by neutral and alkaline soils.
Iron (Fe)	5.0	20.0	Not toxic to plants in aerated soils, but can contribute to soil acidification and loss of essential phosphorus and molybdenum.
Lead (Pb)	5.0	10.0	Can inhibit plant cell growth at very high concentrations.
Lithium (Li)	2.5	2.5	Tolerated by most crops at up to 5 mg/L; mobile in soil. Toxic to citrus at low doses recommended limit is 0.075 mg/L.
Manganese (Mg)	0.2	10.0	Toxic to a number of crops at a few-tenths to a few mg/L in acid soils.
Molybdenum (Mo)	0.01	0.05	Nontoxic to plants at normal concentrations in soil and water. Can be toxic to livestock if forage is grown in soils with high levels of available molybdenum.
Nickel (Ni)	0.2	2.0	Toxic to a number of plants at 0.5 to 1.0 mg/L; reduced toxicity at neutral or alkaline pH.
Selenium (Se)	0.02	0.02	Toxic to plants at low concentrations and to livestock if forage is grown in soils with low levels of added selenium.
Vanadium (V)	0.1	1.0	Toxic to many plants at relatively low concentrations.
Zinc (Zn)	2.0	10.0	Toxic to many plants at widely varying concentrations; reduced toxicity at increased pH (6 or above) and in fine-textured or organic soils.

*Adapted from reference [21].

Table-3. Levels of trace and toxic elements in Phulali canal water determined at various locations.

Sample Code	Time (Hrs)	Na (mg/L)	K (mg/L)	Ca (mg/L)	Mg (mg/L)	Pb (mg/L)	Cd (mg/L)	Cu (mg/L)	Ni (mg/L)	Al (mg/L)	Ba (mg/L)	Zn (mg/L)	Mn (mg/L)	Cr (mg/L)	Fe (mg/L)	Co (mg/L)
	[1]NEQs.	-	-	75***	50***	0.50	0.10	1.0	1.00	5.0	1.5	5.0	1.50	1.0	2.0	0.05
	[2]DWL	150	12	100	50	0.05	0.005	1.0	0.001	0.2	0.1	0.01	0.05	0.05	0.03	---
	[3]LUL	---	---	---	---	0.1**	0.05	0.5	---	---	---	24	---	1.0	---	1.0
	[4]IWL	---	---	---	---	5.0	0.01	200	0.2	---	---	2.0	0.2	0.1	0.5	0.05
	[5]ALP	---	---	---	---	0.01	0.5	5.4	0.01	---	---	0.05	0.50	0.01	0.36	---
P-1	11.00	22.193	7.302	51.352	20.562	0.026	0.003	0.011	0.001	0.113	0.536	0.159	0.251	0.035	0.834	0.086
P-2	11.45	45.778	10.343	83.446	12.253	0.022	0.002	0.010	0.005	1.457	0.576	0.167	0.565	0.035	1.451	0.086
P-3	12.30	29.057	6.288	59.798	17.982	0.017	0.004	0.015	0.002	1.592	0.496	0.092	0.596	0.058	1.427	0.134
P-4	13.05	21.152	7.640	56.419	63.013	0.022	0.002	0.011	0.002	1.507	0.376	0.048	0.412	0.058	1.145	0.151
P-5	13.35	30.809	11.697	61.487	35.521	0.022	0.002	0.021	0.002	0.973	0.357	0.037	0.469	0.082	0.913	0.118
P-6	14.30	23.017	7.978	68.243	249.53	0.024	0.002	0.063	0.001	0.823	0.276	0.041	0.277	0.071	1.122	0.086
Range	-	21.15-45.78	6.28-11.70	51.35-83.45	12.25-249.53	0.01-0.03	0.002-0.004	0.01-0.06	0.001-0.005	0.11-1.59	0.27-0.57	0.03-0.17	0.25-0.60	0.03-0.08	0.83-1.45	0.08-0.15
Average	-	28.668	8.541	63.458	66.477	0.022	0.003	0.022	0.002	1.078	0.436	0.091	0.428	0.057	1.149	0.110
*Skewness	-	1.570	0.805	1.238	2.244	-0.843	1.537	2.247	1.840	-1.069	-0.164	0.584	-0.174	-0.011	0.090	0.518
*Kurtosis		2.52	-0.72	1.73	5.15	1.93	1.43	5.16	3.91	0.56	-1.77	-2.13	-1.87	-1.36	-1.71	-1.84
SD	-	± 9.250	±2.047	±11.277	±91.519	±0.003	±0.001	±0.021	±0.001	±0.566	±0.117	±0.059	±0.144	±0.019	±0.255	±0.028

*Positive skewness indicates a distribution with an asymmetric tail extending toward more positive values and negative skewness indicates a distribution with an asymmetric tail extending toward more negative values. Positive kurtosis indicates a relatively peaked distribution and negative kurtosis indicates a relatively flat distribution.
**Lead is accumulative and problems may begin at threshold value=0.05 mg/L. ***Pakistan Standard Institute, Drinking water quality standards. --- No data available.

[1]National Environmental Quality standards (NEQs) for municipal and liquid industrial effluents. [2]Drinking water limits, [3]Livestock upper limits, [4]Irrigation water limits and [5]aquatic life protection limits by WHO, European, EEC, Federal Republic of Germany, U.S. Department of Agriculture, Natural Resources Conservation Service water-quality guidelines and U.S. EPA maximum contaminant level or action level: revised October 13, 1999 [Ref. # 37].

the percentage of salinity, which has serious effects on both human life and crop yield. Waters high in sodium are considered 'soft' and are generally undesirable for irrigation. Unfavorable conditions are likely to develop when the concentration of sodium exceeds that of calcium plus magnesium. SAR results have been discussed elsewhere [3]. When clay particles adsorb the sodium, they tend to disperse and create 'slick spots'. Sodium-affected soils take water slowly and form dry, hard clods that melt when wetted and tend to seal the soil surface, leaving a slick appearance. Sodium not only affects the soil structure, but also may have a toxic effect on plants. Direct affects of sodium toxicity involve the accumulation of this ion to toxic levels, which is generally limited to woody species. Indirect effects resulting from sodium toxicity include nutritional imbalance and impairment of the physical conditions of the soil [1, 25 -27].

The maximum load of potassium has been found at point 5 and is 11.697 mg/l. Potassium is an essential plant nutrient commonly found in good supply irrigation water but its determination is no longer a routine part of irrigation water analysis. High concentrations of potassium may introduce a magnesium deficiency and iron chlorosis. An imbalance of magnesium and potassium may be toxic, but the effects of both can be reduced by high calcium levels [4, 28].

The highest value for lead is observed at point 1 *i.e.* 0.026 mg/l and all samples exceed the aquatic life protection limits *i.e.* 0.01 mg/l. Excessive levels can cause Pb poisoning because canal water is also used for drinking of cattle and human beings. Symptoms of Pb poisoning in cattle include dullness, lack of appetite, abdominal pain with constipation, sometimes followed diarrhea, and after two or three days, bellowing, staggering, snapping of eyelids, muscular twitching, frothing at the mouth, and convulsive seizures may appear [20, 29].

Excess amount of cadmium observed is 0.004 mg/l and is in safe limits. Symptoms of Cd poisoning in cattle include poor appetite, slower growth, anemia, retarded testicular development, enlarge joints, scaly skin, liver and kidney damage and increase mortality. Point 6 shows highest value *i.e.* 0.063 mg/l for copper and is also in safe limits. Levels above 50 $mgkg^{-1}$ may be potentially dangerous to animal's health while above 250 $mgkg^{-1}$ could be lethal [20, 30].

The highest levels for nickel, barium, zinc and iron are observed at point 2 and are 0.005 mg/l, 0.576 mg/l, 0.167 mg/l, 1.451 mg/l respectively. Nickel, barium, zinc and iron levels are mostly higher than drinking water limits *i.e.* 0.001 mg/l, 0.1 mg/l, 0.01 mg/l and 0.03 mg/l respectively. Zinc and iron levels also observed higher than aquatic life restriction limits. Irrigation and drinking water limits for iron are 0.5 mg/l and 0.03 mg/l respectively and all samples have levels above these threshold limits. The levels of these elements in green forages irrigated by polluted canal water may be variable depending upon the degree of soil contamination [20, 30].

The highest levels for aluminium, manganese and cadmium are observed at point 3 and are 1.592 mg/l, 0.596 mg/l, and 0.004 mg/l respectively. Again the levels of these elements exceed standards for drinking water, aquatic life, livestock and irrigation water restrictions. Cobalt levels (Table-3) are higher than NEQs and irrigation water standards. The concentration of total cobalt in freshwaters is generally low ($\leq$1 μg/L). Higher concentrations are generally associated with industrialized areas. It is recommended that the interim maximum concentration of total cobalt should not exceed 110 μg/L to protect aquatic life in the freshwater environment from acute effects of cobalt [21].

Chromium levels also exceed for drinking water and aquatic life protection limits *i.e.* 0.05 mg/l and 0.01 mg/l respectively. The irrigation water restriction level for manganese, iron and cobalt are 0.2 mg/l, 0.5 mg/l and 0.05 mg/l respectively and at present canal water is not suitable for irrigating the crops [9]. The overall evaluation of the mean concentration levels (Table 3) of the metals in canal water samples is observed to follow the following pattern: > Mg > Ca > Na > K > Fe > Al > Ba > Mn > Co > Zn > Cr > Pb = Cu > Cd > Ni.

Skewness characterizes the degree of asymmetry of a distribution around its mean. Lead, aluminium, barium, manganese and chromium have negative skewness while all other metals have positive skewness. Kurtosis characterizes the relative peakedness or flatness of a distribution compared with the normal distribution. Relative flat distribution is found for potassium, barium, zinc, manganese, chromium, iron and cobalt while relative peaked distribution is observed for the levels of rest of the elements (Table-3). The study, therefore, evidences that each sample of every canal water sampling station is quite specific in terms of their metal distribution.

The linear correlation between pairs of metals is best explained mathematically in terms of the Pearson correlation coefficient *'r'* which is a direct measure of interdependence of a set of variables. The

Table 4. Linear correlation coefficient matrix for selected elements studied in phulali canal water ($n = 6$).

	Na	K	Ca	Mg	Pb	Cd	Cu	Ni	Al	Ba	Zn	Mn	Cr	Fe
K	0.578													
Ca	0.845	0.491												
Mg	-0.407	-0.138	0.118											
Pb	-0.283	0.169	-0.122	0.310										
Cd	-0.147	-0.671	-0.412	-0.373	-0.519									
Cu	-0.303	-0.041	0.168	0.963	0.238	-0.285								
Ni	0.932	0.478	0.811	-0.445	-0.280	-0.244	-0.435							
Al	0.418	0.025	0.418	-0.178	-0.820	0.027	-0.217	0.566						
Ba	0.546	-0.093	0.179	-0.778	-0.126	0.448	-0.748	0.556	0.032					
Zn	0.491	-0.087	0.257	-0.538	0.188	0.286	-0.522	0.481	-0.216	0.929				
Mn	0.695	0.215	0.442	-0.553	-0.861	0.263	-0.469	0.699	0.829	0.398	0.107			
Cr	-0.305	0.287	-0.156	0.455	-0.228	-0.234	0.533	-0.413	0.143	-0.857	-0.936	-0.004		
Fe	0.594	-0.160	0.641	-0.112	-0.709	0.227	-0.112	0.666	0.821	0.340	0.212	0.757	-0.237	
Co	-0.305	-0.226	-0.434	-0.272	-0.620	0.197	-0.362	-0.115	0.612	-0.214	-0.523	0.406	0.366	0.154

Values >0.300 or <-0.300 are significant at $p < 0.01$

statistical linear correlation study at $p < 0.01$ (Table 4) showed strong positive correlations for Na-Ni (r = 0.932), K-Ca (r = 0.491), Ca-Ni (r = 0.811), Mg-Cu (r = 0.963), Pb-Cu (r = 0.938), Cd-Ba (r = 0.448), Cu-Cr (r = 0.533), Ni-Mn (r = 0.699), Al-Mn (r = 0.829), Ba-Zn (r = 0.929), Zn-Fe (r = 0.212), Mn-Fe (r = 0.757), Cr-Co (r = 0.366) and Fe-Co (r = 0.154). These strong positive correlations evidence that the metals might have their origin from industrial and municipal liquid effluents being added to the canal water.

Observation shows that most of the samples, collected from different points, have the values for metals within the legal recommendation for irrigation water. Standards should also be framed by the country for fresh water being used to the cattle. Water from point 1 (before entering the canal in city premises) has the minimum observed values than all other points.

Experimental

Description of the investigated area

Six sampling points were selected at different distances starting from Ghulam Muhammad Barrage to Bihari Colony Bridge *i.e.* 20 km away from the initial point (Fig:1). Mostly samples were collected near sewage water pumping stations being discharged into Phulali canal.

Collection of water samples

Sub-surface canal water samples were collected by using a Rutner sampler of fiberglass made. Mobile vane with essential laboratory equipments of the 'NCE in Analytical Chemistry–Jamshoro' was used and all samples were collected from 11 hrs to 14.30 hrs of the same day.

Preservation of samples

The samples were collected in pre-washed polythene containers and acid washed glass bottles. For metal elements determination, acidified immediately after collection, with the addition of 2 ml ultra pure HNO_3 per liter of canal water and then carefully preserved in a refrigerator at 4°C for laboratory analysis. All the tests were conducted according to standard methods [12, 31].

Digestion of samples

250 ml of well-mixed acidified water sample was kept in Pyrex beaker and evaporated the samples on water bath (temperature ± 100°C) placing watch glass on each beaker to about dryness. 5 ml of 2 M HNO_3 was added in each beaker, digested on water bath, filtered by a Whatman 42 filter paper and filtrate was made to 25 ml with de-ionised water in a 25 ml volumetric flask. Blank digestion was carried out for each sample [12, 31, 32].

Atomic absorption spectrophotometer measurements

The digested samples were analysed by using air-acetylene flame in combination with single element hollow cathode lamps into an Atomic Absorption Spectrophotometer Hitachi model 180 – 50. The statistical data for standards of elements and recommended and experimental setting values for different elements are given in table 5 and 6 respectively. The blanks were used for zeroing the instrument before each analysis to avoid matrix interference. All reagents used were of ultrahigh purity (certified > 99.9%) procured from E-Merck, Germany, or British Drug House Chemicals Ltd., Poole, UK (BDH). Triplicate sub-samples of each sample were run separately in order to record average metal concentrations [11, 10, 33–36].

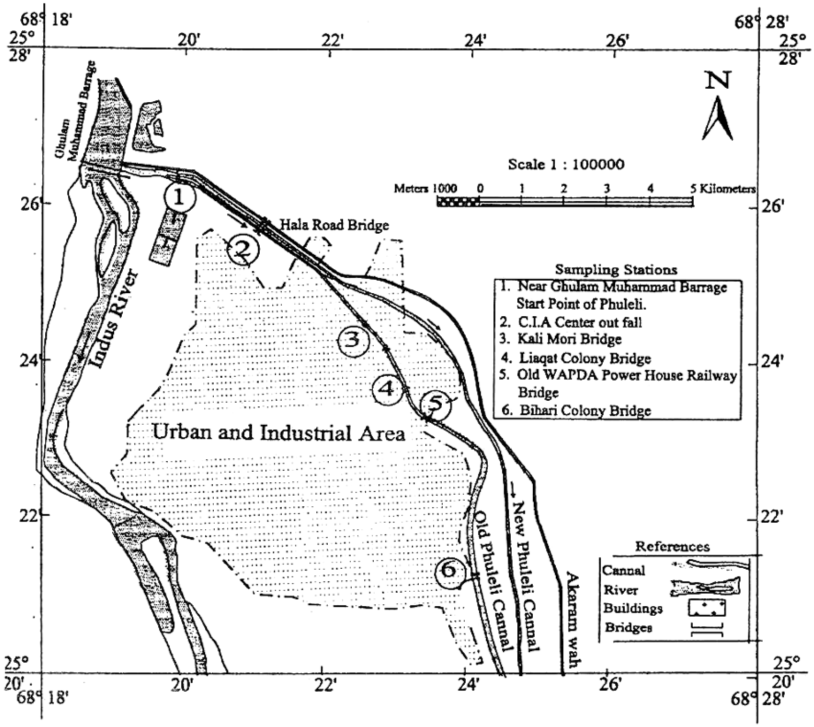

Fig. 1, Map showing the sampling locations of Phulali canal passing through Hyderabad city.

Table 5. Statistical Data for Standard of Elements.

Elements	Conc. Range in ppm (X)	Absorption range	*Statistical calculation y = m x + c* m	c	R^2
Calcium	0.0 – 5.0	0.0 – 0.168	0.0329	0.0031	0.996
Magnesium	0.0 – 1.0	0.0 – 0.637	0.641	-0.0033	0.999
Sodium	0.0 – 2.0	0.0 – 1.3	0.645	0.0092	0.999
Potassium	0.0 – 1.0	0.0 – 0.191	0.1898	0.0038	0.998
Iron	0.0 – 1.0	0.0 – 0.091	0.0904	0.0015	0.999
Nickel	0.0 – 1.0	0.0 – 0.063	0.0627	0.0027	0.992
Copper	0.0 – 1.0	0.0 – 0.0865	0.0861	0.0009	0.997
Zinc	0.0 – 1.0	0.0 – 0.197	0.1962	0.0008	0.999
Lead	0.0 – 1.0	0.0 – 0.168	0.0166	-0.0002	0.998
Cadmium	0.0 – 1.0	0.0 – 0.175	0.1753	0.0010	0.999
Aluminium	0.0 – 10.0	0.0 – 0.35	0.0033	-0.0003	0.999
Barium	0.0 – 5.0	0.0 – 30*	6.032	-0.5200	0.998
Chromium	0.0 – 0.25	0.0 – 22*	88.32	-0.3600	0.998
Cobalt	0.0 – 1.0	0.0 – 0.029	0.0293	-0.0004	0.999
Manganese	0.0 – 1.0	0.0 – 0.188	0.1858	0.0030	0.999

Key: * = y is division of recorder at expansion × 5

Table 6. Recommended and Experimental setting values for different elements of AAS Hitachi model 180-50.

Elements	Lamp Current mA		Wavelength nm		Burner height mm		Slit width nm		Oxidant (Air - kg/cm²)		Fuel (Acetylene - kg/cm²)		Flow rate (Air – min⁻¹)		Flow rate (Acetylene-min⁻¹)		Signal out put
	Recomd Values	Expt. Values	Recomd Values	Expt Values	Recomd Values	Expt. Values	Recomd Values	Expt. Values	Recomd Values	Expt Values	Recomd. Values	Expt. Values	Recomd Values	Expt. Values	Recomd. Values	Expt. Values	
Ca	07.5	7.0	422.7	423.0	12.5	12.5	2.6	2.6	1.60	1.60	0.4	0.4	9.41	9.41	2.61	2.61	100%
Mg	07.5	7.0	285.2	285.5	7.5	7.5	2.6	2.6	1.60	1.60	0.2	0.2	9.41	9.41	2.01	2.01	100%
Na	10.0	7.5	589.0	590.2	7.5	7.5	0.4	0.4	1.60	1.60	0.25	0.25	9.41	9.41	2.21	2.21	100%
K	10.0	7.5	766.5	766.8	7.5	7.5	2.6	2.6	1.60	1.60	0.3	0.3	9.41	9.41	2.31	2.31	100%
Fe	10.0	7.5	248.3	248.5	7.5	7.5	0.2	0.2	1.60	1.60	0.3	0.3	9.41	9.41	2.301	2.301	100%
Ni	10.0	9.5	232.0	232.3	7.5	7.5	0.2	0.2	1.60	1.60	0.30	0.30	9.41	9.41	2.301	2.301	100%
Cu	07.5	7.0	324.8	325.0	7.5	7.5	1.3	1.3	1.60	1.60	0.3	0.3	9.41	9.41	2.30	2.30	100%
Zn	10.0	7.0	213.8	214.0	7.5	7.5	1.3	1.3	1.60	1.60	0.20	0.20	9.41	9.41	2.01	2.01	100%
Pb	07.5	7.0	283.3	283.3	7.5	7.5	1.3	1.3	1.60	1.60	0.30	0.30	9.41	9.41	2.301	2.301	100%
Cd	07.5	7.0	228.8	229.0	7.5	7.5	1.3	1.3	1.60	1.60	0.30	0.30	9.41	9.41	2.31	2.31	100%
Al*	10.0	9.5	309.3	309.5	12.5	12.5	1.3	1.3	1.60	1.60	0.45	0.45	5.91	5.91	5.61	5.61	100%
Ba	10.0	9.5	553.6	553.8	7.5	7.5	1.3	1.3	1.60	1.60	0.45	0.45	5.91	5.91	5.61	5.61	100%
Cr	07.5	6.0	357.9	358.2	7.5	7.5	1.3	1.3	1.60	1.60	0.35	0.35	9.41	9.41	2.301	2.301	100%
Co	10.0	7.5	240.7	250.0	10	10	0.2	0.2	1.60	1.60	0.35	0.35	9.41	9.41	2.51	2.51	100%
Mn	07.5	7.0	279.5	279.7	7.5	7.5	0.4	0.4	1.60	1.60	0.3	0.3	9.41	9.41	2.301	2.301	100%

*Oxidant (Nitrous oxide)

Analytical precision

A parallel comparative check on the accuracy of quantified results was made through the use of standard reference material provided by E-Merck. The reproducibility of the analytical procedures was checked by carrying out a triplicate analysis of each sample. Triplicate results did not differ by more than 5 % of the mean [31].

Statistical analysis

The data was statistically analysed by using SPSS 12 and STATSICA (StatSoft 1999) softwares on P-IV system. The concentrations of elements in canal water samples were correlated by linear correlation coefficient matrix (pearson).

Conclusions

Inorganic trace elements are different from synthetic organic compounds (pesticides) in that they are commonly present at low levels in nature and there is already a natural level of tolerance. There is, however, a fine division between natural tolerance and toxicity. It is therefore essential to have good information on the concentration of these elements in the drainage water in order to develop safe re-use and disposal methods. There is a need that all such industries where more water use is involved should immediately arrange for treatment of their wastewater before discharging. More study is needed to monitor these levels in effected crops, blood serum of cattle and human beings [37]. The observed levels in polluted canal water can affect animal's health and milk quality, which may become potentially toxic to the consumers. The possibility of serious health implications with continuous consumption cannot be eliminated.

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