Journal of Applied and Natural Science 5 (1): 132-136 (2013)

JANS

Impact of industrial effluents on ground water and soil quality in the vicinity of industrial area of Panipat city, India

Pawan K. Bharti[1, 2]*, Pawan Kumar[2] and Vijender Singh[3]

[1]Center for Agro-Rural Technologies (CART-India), 20, Jamaalpur Man, Raja Ka Tajpur, Bijnore - 246735 (UP), INDIA
[2]Department of Zoology and Environmental Science, Gurukula Kangri University, Hardwar – 249404 (Uttarakhand), INDIA
[3]Haryana Test House, Panipat (Haryana), INDIA
*Corresponding author. E-mail:gurupawanbharti@rediffmail.com

Received:August 25, 2011; Revised received:March 5, 2013; Accepted:March 30, 2013

Abstract: The present paper is aimed towards the assessment of heavy metal contamination of agricultural soil due to irrigation with contaminated ground water affected by textile industrial effluents at Panipat city in India. Samples of ground water and irrigated soils from textile industrial area were analyzed for various heavy metals, viz. Mn, Ni, Fe, Cu, Cd, Pb and Zn, using Atomic Absorption Spectrophotometry. Metal transfer factors from ground water to irrigated agricultural soil and from soil to ground water were calculated for heavy metals. The findings deal with the distribution of heavy metals in ground water of industrial area and irrigated agricultural soil. Transfer factors for heavy metals from effluent to ground water were observed to be 0.436, 1.180, 6.461, 2.401, 2.790, 3.178 and 0.634 for Cd, Cu, Fe, Mn, Ni, Pb and Zn respectively. These were found to be very high from ground water to agriculture soil due to the natural shale value of heavy metals in soil system. Thus, untreated industrial effluents can cause an environmental threat to ground water resources and affects soil quality and agricultural plant productivity.

Keywords: Agriculture soil, Groundwater, Heavy metals, Industrial effluent,Transfer factor

INTRODUCTION

Textile industries consume a large quantity of water and generate a huge amount of wastewater, which are generally discharged into a common effluent drain of industrial area. The composite effluents from textile industries in Panipat city consisting high concentrations of heavy metals, organic pollutants and toxic colours, which may affect the quality of surface water, soil, ground water and plant tissues of the region. Toxic pollutants may percolate down via soil profile and reach in ground water, which ultimately cause the health hazards among human being and livestock after consumption as daily drinking requirements (Malik and Bharti, 2010). The waste water without any treatment may cause adverse effect on the health of human, domestic animals, wildlife and environment. Contaminated ground water has deteriorated the drinking water and impacts on soil systems and crop productivity.

Heavy metals are usually present in trace amounts in natural water but many of them are toxic even at very low concentration though many of the metals are essential components of the biological system. Metals such as As, Pb, Cd, Ni, Hg, Cr, Co, Zn and Se are highly toxic even in minor quantity. Increasing quantity of heavy metals in aquatic resources is currently an area of greater concern especially since a large number of industries discharge their metal containing effluents in to fresh water without any adequate treatment (Canter, 1987).

Contaminated water when used for irrigation purpose affects soil quality and crop health of the agricultural system. The textile effluent had consisting high concentration of trace heavy metals and through its accumulation in different trophic levels of ecosystem ultimately cause the health hazards among livestock and human beings (Malik *et al.*, 2004). So, it is very much essential to assess the quality of wastewater before discharging it and to develop an economical method for the prevention and control of ground water pollution. Ground water contaminated by textile effluents, has impact on agriculture irrigation, drinking utilities, soil and agricultural systems (Bharti and Chauhan, 2013). So, it is essential to assess the status of industrial effluent and distribution and dispersion of heavy metals in the environment of the vicinity of industrial area.

MATERIALS AND METHODS

Panipat is situated on the bank of river Yamuna (29' 09' 50'' and 29' 50' North latitude and 76° 31' 15'' and 77° 12' 45'' East longitude) with a height of 255 m asl bordering Karnal, Sonipat, Jind, Kaithal districts of Haryana and Uttar Pradesh . Panipat town is located on the National highway no.1 about 90 km toward north of Delhi has a population of about 0.27 million. Average population density of the urban area of Panipat city is 25,278 per Sq. Km. Study point (Textile industrial area /Dye houses) in

ISSN : 0974-9411 (Print), 2231-5209 (Online)

Panipat city is situated on Jatal road in industrial area near GT Road, quite famous for handloom business (Malik *et al.*, 2006).

Sampling: Textile effluents in composite forms were collected from common effluent drain of dye houses and surface water samples were collected from the nearest small water bodies, while pond water was collected from a large pond (12 ha) contaminated by textile effluents. The ground water samples were collected from hand pumps / tube wells of village Binjhole situated near industrial area, where the effluent drain ends up into a pond and percolate down into shallow aquifers. Soil samples were collected from the agricultural fields near textile industrial area. Soil samples were collected in polythene bags and transported to laboratory. Approximately 500gm soil sample was collected from a depth of 15 cm from each site. A total number of 21 water and 9 soil samples were collected and preserved.

Samples collected in Borosil BOD bottles and some Jeri canes for laboratory experiments. Some parameters were determined immediately on sampling sites and for rest of the parameters and heavy metals, samples were stored in refrigerator at 4°C.

Digestion and analysis: Water/soil samples were acidified in the field with concentrated HNO_3 (5 ml/l of water sample to reduce the pH of the sample, pH > 2.0) for the total metal estimation. Total metal content in soil was determined by digesting 0.5 g of soil/ sediment sample from each site with a mixture of Conc HNO_3 and $HClO_4$ (10 ml + 2 ml). The digested samples were filtered through Whatman filter No. 42 and finally volumes were made 10 ml with 0.1 N HNO_3 and analyzed for heavy metals using Atomic Absorption Spectrophotometer (Model ECIL-4129). All water and effluent samples were analyzed for physico-chemical parameters and heavy metal using standard methods Trivedi and Goel (1984) and (APHA, 2005).Transfer factor between ground water and soil, was calculated for each metal according to the following formula:

TF = S*w* (mg g^{-1} dry wt)/W*t* (mg g^{-1} dry wt), where S*w* is the soil metal content originating from the ground water irrigation and W*t* is the total metal content in ground water.

RESULTS AND DISCUSSION

As the major source of pollution are dye houses of textile industries in Panipat region metals in the effluents reach the pond water and percolate down to ground water. Ground water is mostly used for irrigation of agricultural fields in most part of Haryana state, and therefore, due to the repeated irrigation practices, agricultural soil quality may be altered.

General characteristics of effluent and heavy metal content are present in Table 1 and Table 2 respectively. The physico-chemical parameters of ground water and agricultural soil are depicted in Table 3 and Table 4 to know the general characteristics and behaviour of ground water and soil. The comparative average concentrations of heavy metals in ground water and irrigated agricultural soil are given in Table 5 and Table 6. The results showed that the concentrations of some metals like Pb and Fe are present in ground water in excess quantity (0.74 and 2.76 mg l^{-1}). The metals like Mn, Ni, Cu, Cd and Zn were found in ground water as an average of 0.26, 0.07, 0.3, 0.006 and 0.1 mg l^{-1} respectively. In Panipat industrial area, metals from surface water may percolate down in to shallow aquifers via soil profile after delaying a long period (Kumar *et al.*, 2001). Leaching effect of heavy metals result as the excess amount of these metals in the ground water of the region, which

Table 1. Physico-chemical parameters of composite industrial effluent.

Parameters (Unit)	Summer	Monsoon	Winter
	Mean±SD	Mean±SD	Mean±SD
Temperature (°C)	30.87±3.42	32.83±2.65	26.12±1.04
pH	9.91±0.39	10.72±0.75	10.16±0.29
TS (mg/l)	2479.25±109.11	2643.67±220.73	2262.75±31.24
TSS (mg/l)	259.5±66.84	570.67±94.87	165.75±83.69
TDS (mg/l)	2219.75±55.18	2073±193.91	2097±52.89
EC (mho/cm)	3.45±0.09	3.27±0.31	3.24±0.13
DO (mg/l)	1.2±0.91	3.23±1.25	3.52±0.47
Free-CO_2 (mg/l)	2.5±0.72	0.73±1.27	0.42±0.49
BOD(mg/l)	162.5±23.12	158.33±14.57	157±21.43
COD(mg/l)	415±48.71	437.33±20.40	386.5±47.33
Total alkalinity (mg/l)	813.5±77.35	889±47.88	642.5±73.53
Ca (mg/l)	20.25±6.95	27.37±6.78	11.45±3.84
Mg (mg/l)	13.27±6.73	16.07±2.67	8.95±2.43
K (mg/l)	7.75±0.71	8.83±0.57	7.95±0.23
Cl (mg/l)	657.25±95.50	825.67±29.94	691.75±55.02
Na (mg/l)	152.75±8.30	177±7.21	153.75±3.5

Table 2. Heavy metals in composite industrial effluent.

Heavy metals	Summer	Monsoon	Winter
	Mean±SD	Mean±SD	Mean±SD
Cadmium (ppm)	0.028±0.01	0.009±0.001	0.005±0.004
Copper (ppm)	0.430±0.13	0.367±0.09	0.180±0.030
Iron (ppm)	0.542±0.17	0.287±0.13	0.240±0.100
Manganese (ppm)	0.176±0.06	0.110±0.02	0.215±0.034
Nickel (ppm)	0.066±0.04	0.007±0.003	0.029±0.012
Lead (ppm)	0.475±0.11	0.330±0.03	0.407±0.158
Zinc (ppm)	0.222±0.09	0.165±0.06	0.337±0.146

Table 3. Physico-chemical parameters of ground water in industrial area.

Parameters (Unit)	Summer	Monsoon	Winter
	Mean±SD	Mean±SD	Mean±SD
Temperature (°C)	31.43±2.18	31.50±2.78	25.60±0.65
pH	7.70±0.10	7.43±0.05	7.46±0.11
TS (mg/l)	1464.67±191.19	1229.00±154.08	797.20±165.91
TSS (mg/l)	133.00±21.51	120.66±16.92	79.00±14.82
TDS (mg/l)	1331.67±169.74	1108.33±137.51	718.20±151.14
EC (mho/cm)	2.08±0.26	1.73±0.21	1.12±0.24
DO (mg/l)	2.56±0.21	3.96±0.68	3.80±0.60
Free-CO_2 (mg/l)	0.93±0.15	0.16±0.29	0.22±0.30
BOD(mg/l)	35.67±8.14	31.33±23.16	14.40±11.15
COD(mg/l)	93.00±16.52	75.00±48.77	37.00±30.72
Total alkalinity (mg/l)	557.67±59.74	584.66±23.71	493.60±31.06
Ca (mg/l)	106.67±15.27	136.66±51.32	46.00±16.73
Mg (mg/l)	92.67±25.42	88.00±32.60	32.40±16.23
K (mg/l)	5.27±0.57	6.10±0.10	5.28±0.32
Cl (mg/l)	104.33±34.27	145.00±33.15	72.20±35.25
Na (mg/l)	88.33±4.16	95.00±11.79	51.00±13.45

Table 4. Physico-chemical parameters of agricultural soil.

Parameters (Unit)	Summer	Monsoon	Winter
	Mean±SD	Mean±SD	Mean±SD
Temperature (°C)	27.87±3.56	26.20±2.55	17.40±3.92
WHC (%)	43.75±0.48	36.13±4.92	36.94±2.83
Bulk density (mg/cm^3)	1.15±0.03	1.22±0.03	1.19±0.08
Soil moisture (%)	3.52±1.04	10.64±2.42	5.27±1.18
pH	7.30±0.20	7.56±0.18	7.32±0.32
EC (mho/cm)	27.67±2.08	26.50±1.32	24.18±1.12
Cl (µg/g)	734.33±112.01	641.67±69.29	514.80±71.52
Na (µg/g)	537.33±125.08	192.00±91.99	363.40±157.27
K (µg/g)	35.00±2.00	31.00±1.00	34.40±1.52

may cause health problems to human beings, cattle and plants also (Bharti, 2007).

It was found that the average concentrations of heavy metals, i.e. Cd, Cu, Fe, Mn, Ni, Pb and Zn in the surface soil were 1.927, 26.633, 44.078, 9.90, 7.96, 42.358 and 13.127 mg g^{-1} respectively, among these Fe, Pb, Cu were in high level due to their cumulative and adsorptive nature in soil after repeated irrigation by contaminated ground water. Cd and Zn were found minimum due to their weak adsorptive nature in soil (Mido and Satake, 2003). Also, these metals are naturally occurring elements in earth crust (Bharti, 2012b).

Table 5. Seasonal variation in heavy metals in ground water and agricultural soil.

Heavy metals	Ground water			Agriculture soil		
	Summer	Monsoon	Winter	Summer	Monsoon	Winter
	Mean±SD	Mean±SD	Mean±SD	Mean±SD	Mean±SD	Mean±SD
Cadmium (ppm)	0.008±0.002	0.003±0.003	0.007±0.001	3.33±0.61	0.67±0.55	1.78±0.44
Copper (ppm)	0.44±0.07	0.41±0.14	0.29±0.09	36.30±7.42	30.20±5.34	13.40±5.97
Iron (ppm)	3.77±0.89	1.50±0.24	1.63±0.92	76.67±16.80	26.77±10.77	28.80±13.22
Manganese (ppm)	0.55±0.07	0.37±0.15	0.28±0.08	13.57±1.40	10.23±2.38	5.90±2.79
Nickel (ppm)	0.15±0.01	0.09±0.02	0.05±0.04	10.47±0.75	7.63±1.14	5.78±1.24
Lead (ppm)	1.84±0.31	1.16±0.21	0.85±0.24	62.40±10.92	39.33±11.67	25.34±9.23
Zinc (ppm)	0.20±0.04	0.13±0.02	0.13±0.05	13.17±3.91	18.53±5.15	7.68±2.80

Table 6. Heavy metals (mean value) in effluent, ground water and agricultural soil samples.

Metals (ppm)	Effluent (mg l^{-1})	Ground water (mg l^{-1})	Agricultural soil (µg g^{-1})
Cadmium (ppm)	0.014	0.006	1.927
Copper (ppm)	0.326	0.384	26.633
Iron (ppm)	0.356	2.303	44.078
Manganese (ppm)	0.167	0.402	9.900
Nickel (ppm)	0.034	0.095	7.960
Lead (ppm)	0.404	1.284	42.358
Zinc (ppm)	0.242	0.153	13.127

Table 7. Transfer factor between from effluent to ground water; from ground water to irrigated agricultural soil and from soil system to ground water.

Metals	Effluent vs Ground water	Ground water vs Agricultural soil	Agricultural soil vs Ground water
Cadmium (Cd)	0.436	321.111	0.003
Copper (Cu)	1.180	69.358	0.014
Iron (Fe)	6.461	19.142	0.052
Manganese (Mn)	2.409	24.606	0.041
Nickel (Ni)	2.790	83.497	0.012
Lead (Pb)	3.178	32.980	0.030
Zinc (Zn)	0.634	85.795	0.012

Transfer factors (TF) of different heavy metals from ground water to agricultural soil (GW Vs AGS) is one of the key components of human exposure to metals through the food chain as reported by Lokeshwari and Chandrappa (2006). In present study, the maximum TF values were obtained for Cd (321.111), Zn (85.759), Ni (83.497) from ground water to agricultural soil, while from soil to ground water the TF for metals is comparatively less. Overall TF values of Pb, Fe and Mn were found to be minimum and significant overall at both levels of industrial area. This supports the findings that persistence of Cu and Cd is comparatively less while that of Pb is more in ground water and soil systems. The present study indicated the transfer of heavy metals from ground water to agricultural soil system due to the repeated irrigation practices. Some quantity of heavy metals may again percolate via soil profile and disperses in ground water regime. Soil quality and composition may also alter in irrigated agricultural fields and thus metals are accumulated in next trophic levels, which may seriously cause health hazards to livestock and ultimately to human beings by direct consumption or by uptake the food products originated by cattle or vegetations (De, 2002).

In the study area, textile effluent is the main source of water contamination by leaching. As it is the major source for irrigation in Haryana state, irrigation with contaminated ground water containing variable amounts of heavy metals leads to increase in concentration of metals in the agricultural soil (Malik and Bharti, 2007). Taking into account all environmental conditions, and evaluating the transfer coefficient (TF) of heavy metals between ground water and soil system, it is clear that the contaminated ground water poses negative impact on agricultural soil system due to repeated irrigation, and further may affect the crop plant vegetations and ultimately to human being also (Bharti, 2012a and Bharti, 2012b). It was concluded that the textile effluents are deteriorating the ground water and soil quality with special reference to heavy metals in the vicinity of Panipat industrial area.

ACKNOWLEDGEMENTS

Author (PKB) wants to thank the Head, Department of Zoology and Environmental Science for providing opportunity to execute the environmental study and all analytical work in the Department during the Ph.D. Programme.

REFERENCES

APHA (2005). Standard methods for examination of water and waste water. *American Public Health Association,* 21st edition. Inc, New York. pp: 1170.

Bharti, P.K. (2007). Effect of textile industrial effluents on ground water and soil quality in Panipat region (Haryana), *Ph. D. thesis, Gurukula Kangri University, Hardwar*, pp: 191.

Bharti, P. K. (2012a). Groundwater Pollution, *Biotech Books*, Delhi, pp: 243.

Bharti, P. K. (2012b). Heavy metals in Environment, *Lambert Academic Publishing GmbH & Co. KG, Saarbrucken*, Germany, pp: 70.

Bharti, P. K. and Chauhan, Avnish (2013). Soil quality and contamination, *Discovery Publishing House*, Delhi, pp: 186.

Canter, L.W. (1987). Ground water quality protection, *Lewis publications*. Inc., Chelsea, Ml, pp: 650.

De, A. K. (2002). Environmental Chemistry, *New Age International (Ltd) Publishers, New Delhi*, pp: 392.

Kumar, S., Kushwaha, R., sapra, S., Gupta, A.B. and Bhargava, A. (2001). Impact of textile industry on ground water quality of Sanagar, Jaipur, *J. Indian Water Works Association,* 33(4): 321-326.

Lokeshwari, H. and Chandrappa, G.T. (2006). Impact of heavy metal contamination of Bellandur Lake on soil and cultivated vegetation, *Current Science*, 91(9): 622-627.

Malik, D. S. and Bharti, P.K. (2007). Soil quality of irrigated agricultural fields in textile industrial area of Panipat city, *Asian J. Exp. Sciences*, 21 (2): 445-451.

Malik, D.S. and Bharti, P.K. (2010). Textile Pollution, *Daya Publishing House*, Delhi, pp: 383.

Malik, D.S.; Bharti, P.K. and Grover, S. (2006). Alteration in surface water quality near textile industries at Panipat (Haryana), *Environment Conservation J.*, 7(2): 65-68.

Malik, D.S.; Yadav, R. and Bharti, P.K. (2004). Accumulation of heavy metals in crop plants through irrigation of contaminated ground water in Panipat region, *Environmental Conservation Journal* 5 (3): 101-104.

Mido, Y. and Satake, M. (2003). Chemicals in the environment. In: *Toxic Metals* (Eds. Sethi, M. S. and Iqbal, S. A.), Discovery Publishing House, New Delhi, pp: 45–68.

Trivedi, R.K. and Goel, P.K. (1984). Chemical and biological methods for water pollution studies, *Environmental Publication*, Karad, India, pp: 251.