Assessment of Heavy Metals in the Water Resources of Mirzapur, U.P., India

Vijai Krishna[1] Bhanu Pratap Singh[2] Narendra Kumar Singh[3] Anil Kumar Pandey[4]
[2]M.Sc. (Tech.) [3]Pharmacy
[1,2,3,4]Department of Environmental Engineering
[1,2,4]Institute of Environment and Sustainable Development, (BHU), Varanasi [3]Research Laboratory, Rajiv Gandhi South Campus, (BHU), Mirzapur

Abstract— Water is the basic requirement of the civilizations. Water is used in several ways like bathing, cooking and most important is for drinking. Water may be available either as ground water or surface water resource. Major groundwater resources in India are wells and hand pumps, while the surface water resources include the rivers, ponds, reservoirs, waterfalls etc. Due to rapid rate of development including industrialization, urbanization, intensive agriculture etc. different types of pollutants are reaching to the water resource. These pollutants may be solids or effluents. These pollutants include many types of metals and heavy metals also. These heavy metals reach into human body and cause several disorders. In this study samples have been collected from different types of waters resources of Mirzapur district and analyzed for the concentration of the heavy metals Zn, Cd and Pb, results indicate that concentration of all the three selected metals are higher in many samples of water throughout the district. Concentration of lead is higher than maximum concentration limit in almost all the samples, while cadmium and Zinc are also crossing this limit in many samples.

Key words: Heavy metals, Water resources, Maximum Concentration Limit

I. INTRODUCTION

Water is the most important requirement of the living beings. Water resources are being polluted and through several anthropogenic activities like agriculture in which several types of chemicals are in use like fertilizers, pesticides, herbicides etc. These chemicals reaches to the water bodies through run off. The heavy metals present in these chemical also reaches to the water bodies and degrades its quality. These water bodies are the water resources of a particular area. These may include rivers, ponds, wells, reservoirs, lakes, waterfalls and ground water. Atmospheric depositions of heavy metals have altered the biogeochemical cycles of these elements [1, 2]. The impact of aerially driven pollutant aerosols on inland water bodies has recently received attention [3, 4]. Heavy metals may have serious health implications including carcinogenesis [5]. Studies have indicated that the urban sewage and industrial effluents are the main reason responsible for deteriorating river water quality [6, 7]. Water is one of the essentials components that support all forms of plant and animal life [8]. It is generally obtained from two principal natural sources; surface water like fresh water lakes, rivers, etc. and ground water like borehole water and well water [9, 10]. Water has unique chemical properties due to its polarity and hydrogen bonding means it can dissolve, absorb, adsorb or suspend different compounds [11]. One of the important environmental issues today is ground water contamination [12] and heavy metals receive concern considering their toxicity at low concentrations [13]. Heavy metals have atomic weights between 63.546 and 200.590 with specific gravity greater than 4.0 means five times of water. They may remain in the form of colloidal, particulate and dissolved phases in the water [14]. Heavy metal can cause serious health effects with varied symptoms depending on the nature and quantity of the metal ingested [15]. They produce their toxicity by forming complexes with proteins, in which carboxylic acid (–COOH), amine (–NH2), and thiol (–SH) groups are involved [16]. The quality of ground water resources are affected by the characteristics of the media through which the water passes to the ground water zone of saturation [17]. The heavy metals discharged by industries, solid and hazardous waste sites; fertilizers and accidental oil spillages etc. which can result in a steady rise in contamination of ground water [18, 19].

II. MATERIALS AND METHOD

A. Study Area:

The Mirzapur exists between 23.52 to 25.32 North Latitude and 82.7 to 83.33 East Longitude. It exists in the state of Uttar Pradesh of India. It forms a portion of the Vindhyachal Division. According to Central Statistical Organisation the district of Mirzapur had an area of 4851.9 Km^2. In 2011, population of Mirzapur is 2,496,970 in which male and female population is 1,312,302 and 1,184,668 respectively. Out of the total Mirzapur population from 2011 census, 13.92% lives in urban regions and 86.08% in rural areas [20].

B. Sample Collection and Location:

Water samples were collected from 51 randomly selected location including ground water (hand pumps and wells) and surface water sources (ponds, reservoirs, rivers, municipal supply water and waterfalls etc.). We followed the important highways and taken samples at intervals of 10 k.m.

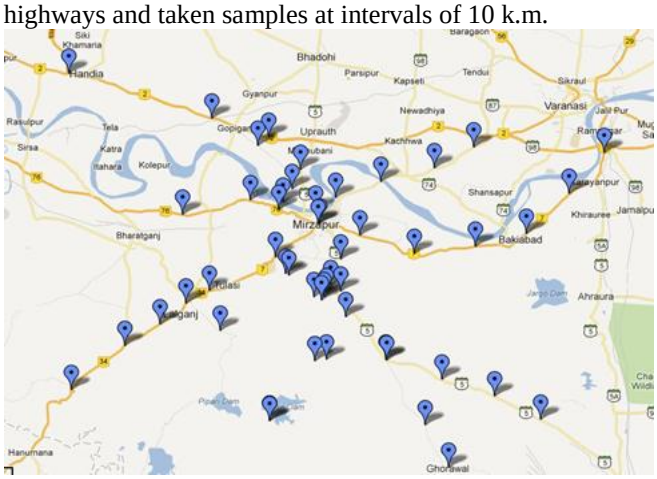

Fig. 1: Highlighted points are sampling points

(Imagery ©2012 Terra Metrics, Map data ©2012 Google, Map IT, Tele Atlas)

C. Standard Preparation:

Standard stock solution of AAS grade for Cd, Pb, Zn were obtained from Merck Specialties private Ltd, India.

D. Sample Analysis:

The water samples were analysed for the presence of, cadmium, lead and zinc using the Atomic Absorption Spectrophotometer (SHIMADZU AA6300). Air-acetylene mixture was used as fuel source. Hollow cathode lamp of the corresponding elements was used as the resonance line source. The concentration of the metal present being displayed in mg/L (ppm) by the instrument with the help of standard curve.

III. Results and Discussions

A. Observation Table:

S. No.	Site Name	Cd (ppm)	Pb (ppm)	Zn (ppm)
Ground Water (Hand pumps/Wells)				
SH-5 From North To South Mirzapur				
01.	Tedwa Bhadohi Road	0.0019	*0.1501*	*0.3549*
02.	Balahara Mod Marihan Block	ND	*0.1000*	*0.7045*
03.	Bahuti Village Balahara	0.0008	*0.0929*	0.1258
04.	Marihan Chouraha	ND	*0.0143*	*0.3042*
05.	Karman Mirzapur	0.0008	*0.0786*	0.0386
06.	Rajgarh Chouki	ND	*0.1072*	*3.0226*
07.	Karma Chouki	0.0004	*0.0858*	*0.7885*
08.	Near Ghorawal	ND	*0.0643*	*0.6109*
Dubar Road Between SH-5 & NH-7/NH-34 From East to West Mirzapur				
09.	Patehra Kala Marihan	0.0019	*0.0286*	*1.8925*
10.	Deepnagar Near Patehrakala	0.0023	*0.1000*	0.0619
11.	Dubarkala Lalganj	ND	*0.0500*	0.0559
NH-7 From North East to South West Mirzapur				
12.	Milkipur Adalhat	0.0027	*0.2072*	*1.0393*
13.	Darra Mirzapur	*0.0050*	*0.1644*	0.0928
14.	Jamuni Mirzapur	*0.0046*	*0.1286*	0.0952
15.	Bhorai Mirzapur	*0.0039*	*0.1715*	*0.3372*
16.	Kapsol Mirzapur	*0.0054*	*0.2001*	*0.7592*
17.	Aghwar Mirzapur	0.0023	*0.1929*	*0.4115*
18.	Mirzapur Vikas Bhawan Pathraiya	ND	*0.0715*	0.1338
19.	Rewa Road Mirzapur	*0.0031*	*0.1501*	*0.5470*
20.	Karanpur Lalganj Mirzapur	0.0023	*0.1072*	0.2066
NH-34 From North East to South West Mirzapur				
21.	Tenduii Lalganj	*0.0031*	*0.1429*	0.2214
22.	Barondha Lalganj Mirzapur	0.0023	*0.1858*	0.1949
23.	Dramandganj Mirzapur	0.0008	*0.0429*	0.1583
NH-76 From East to West Mirzapur				
24.	Vindhyachal Mirzapur	0.0027	*0.2144*	*1.0746*
25.	Akorhi Allahabad Road	*0.0054*	*0.1858*	0.0297
26.	Barai bari Mirzapur	0.0015	*0.1929*	*0.4164*
NH-74 From South West to North East Mirzapur				
27.	Bhatoli Mirzapur	0.0019	*0.1644*	0.2648
28.	Godhna Mirzapur	0.0019	*0.1858*	0.2496
29.	Jogapur Manhgao Mirzapur	*0.0035*	*0.1429*	*0.4204*
MDR-156E From South East to North West Mirzapur				
30.	Hanuman Nagar Gopiganj Road	ND	*0.1644*	0.1254
31.	Almau Halt	0.0027	*0.1715*	*0.8383*
NH-2 From East to West Mirzapur				
32.	Lalanagar Gopiganj Road	*0.0043*	*0.1572*	0.0583
33.	Near Jangiganj	*0.0039*	*0.1358*	0.0579
34.	Handia (Allahabad)	0.0015	*0.1715*	*0.5626*
Balahara Villages Near RGSC				
35.	Fulyari Balahara Mirzapur	ND	*0.0858*	0.0800
36.	Parmapur Near Balahara	0.0012	*0.1000*	0.0273
37.	Near Bahuti Balahara Block Marihan	ND	*0.0643*	0.0201
Near Falls Between SH-5 & NH-34/NH-7				
38.	Tanda Fall Handpump	ND	*0.0715*	0.0225
39.	Sirsi Handpump	0.0008	*0.0214*	0.2717
Water Falls (surface water)				
40.	Tanda Fall Mirzapur	0.0027	*0.0858*	0.0177
41.	Sirsi Fall Mirzapur	ND	*0.0715*	0.0313
42.	Windham Fall Barkachha	ND	*0.0500*	0.0217
Pond and Dam (surface water)				
43.	Lower Khajuri Barkachha	ND	*0.0929*	0.0273
44.	Kotwa Chunari Dam Marihan	ND	*0.0572*	0.0289
River (surface water)				
45.	Vindhyachal Ganga River	0.0019	*0.0643*	0.0149
46.	Mirzapur Pakka Ghat Ganga River	0.0023	*0.0786*	0.0434

47.	Mirzapur Sarvora Ganga River	0.0008	*0.0500*	0.0205
48.	Dhurkar Marihan	0.0027	*0.0572*	0.0261
Supply Water (surface water)				
49.	Mirzapur Railway Station	*0.0046*	*0.1929*	0.0502
50.	Marihan Chouraha	0.0015	*0.0786*	0.2681
51.	Lalganj Mirzapur	0.0008	*0.1143*	0.2074
Drinking Water Standards				
1.	WHO desirable maximum value (Ii), 1993	0.0030	0.0100	3.000
2.	BIS desirable maximum value (Ii); IS 10500, 1993	0.0100	0.0500	5.000

Table 1: The concentration values of the Cd, Pb and Zn in different types of water sources
(The values in italics denotes the values higher than the maximum concentration limit and ND denotes the 'Not Detected')

S. N.	Statistics	Ground water	Surface Water	Both
1.	Number of samples	39	12	51
2.	Number with Cd detected	29	08	37
3.	% detected	74.35%	66.66%	72.54%
4.	Minimum concentration detected (ppm)	0.0004	0.0008	0.0004
5.	Maximum concentration detected (ppm)	0.0054	0.0027	0.0054
6.	WHO maximum concentration limit (ppm)	0.0030	0.0030	0.0030
7.	Number of samples above maximum concentration limit	10	01	11
8.	% above maximum concentration limit	2.56%	8.33%	21.56%

Table 2: Summary statistics of Cadmium analysis

S. N.	Statistics	Ground water	Surface Water	Both
1.	Number of samples	39	12	51
2.	Number with Pb detected	39	12	51
3.	% detected	100%	100%	100%
4.	Minimum concentration detected (ppm)	0.0143	0.05	0.05
5.	Maximum concentration detected (ppm)	0.2144	0.1929	0.2144
6.	WHO maximum concentration limit (ppm)	0.0100	0.0100	0.0100
7.	Number of samples above maximum concentration limit	39	12	51
8.	% above maximum concentration limit	100%	100%	100%

Table 3: Summary statistics of Lead analysis

S. N.	Statistics	Ground water	Surface Water	Both
1.	Number of samples	39	12	51
2.	Number with Zn detected	39	12	51
3.	% detected	100%	100%	100%
4.	Minimum concentration detected (ppm)	0.0201	0.0149	0.0149
5.	Maximum concentration detected (ppm)	3.0226	0.2681	3.0226
6.	WHO maximum concentration limit (ppm)	3.000	3.000	3.000
7.	Number of samples above maximum concentration limit	17	0	17
8.	% above maximum concentration limit	43.58%	0%	33.33%

Table 4: Summary statistics of Zinc analysis

Out of the 51 in 37 samples the cademium is detected which is 72.54% of all samples with the minimum concentration detected was 0.0004 ppm (karma chouki) in ground water while in surface water it was 0.0008 ppm. (Mirzapur Sarvora Ganga River). The maximum concentration detected was 0.0054 ppm (Akorhi Allahabad Road and Kapsol Mirzapur) in ground water and in surface water it was 0.0027 ppm (Dhurkar Marihan and Tanda Fall Mirzapur). Eleven Samples shown results higher than maximum concentration limit of Cademium, in which one sample is from surface water and ten from the ground water. 2.5% samples of ground water and 8.33% Samples of surface water were having concentration higher than the maximum concentration limit of Cd. Overall 21.56% samples were having higher concentration than the maximum concentration limit of Cd.

In case of lead all that is 100% samples detected the presence of lead with minimum concentration detected is 0.0143ppm (Marihan Chouraha) in ground water and in surface water it was 0.0214 ppm (Sirsi Handpump) while the maximum concentration in ground water detected was 0.2144 ppm (Vindhyachal Mirzapur) and in surface water the maximum concentration found was 0.1929 ppm (Mirzapur Railway Station). The study shows that 100% samples were higher than the maximum concentration limit of lead.

In case of Zinc out of 51, all samples were detected the presence of Zinc. The minimum concentration obtained was 0.0201 ppm (Near Bahuti Balahara Block Marihan) in ground water while in surface water it was 0.0149 ppm (Vindhyachal Ganga River). The maximum concentration observed was 3.0226 ppm (Rajgarh Chouki) in ground water but in surface water it was 0.2681ppm (Marihan Chouraha). 43.58% samples of zinc of ground water were found above than the maximum concentration limit of the zinc while in case of surface water no any sample were found to be above than the maximum concentration limit. So in total 33.33%

sample were found to be higher than the maximum concentration limit of zinc.

IV. CONCLUSION

The reflections from the overall sampling which was carried out in the district of Mirzapur in different regions revealed that the water quality of Mirzapur is questionable particularly in respect to Lead. Overall study indicates high contamination of Lead in the groundwater as well as surface water resources of Mirzapur. North-West Mirzapur was found having much contamination of water. Therefore Lead can pose health risk problem to the users. Thus the water is recommended to be treated at the source before their domestic uses. The present study may an important frame of reference to the government on decision-making for water resource improvement. Lead is widely dispersed in the environment, occurring in a variety of sedimentary rocks, and in felsic igneous and metamorphic rocks, where it may reach high concentrations in veins associated with hydrothermal fluids. Under pH conditions generally found in natural waters, lead has a low solubility. Concentrations of lead in water are only likely to be of significance in environment where pH is less than 4.5, and it is very rarely found in water at treatment works. Although lead may be present in source waters, it is unusual except in few areas of mining but possible risks posed by lead in drinking-water should be assessed in localities where lead has been extensively used in materials of plumbing, particularly if the water supplied is corrosive or is likely to dissolve lead. If lead concentrations significantly exceed standard values, this should be appropriate to use mitigating measures, like control of corrosion and replacement of plumbing materials. These results show high concentration of lead in almost all cases and the levels were higher than the WHO specified Maximum Contaminant Level. This suggests a significant risk to this population but the fact is that for a large part of population in this region wells and bore holes are the only sources of their supply of water.

REFERENCES

[1] Azimi, S., A. Ludwig, D. Thevenot & J.L. Colin. (2003)
[2] Friedland, A.J. & E.K. Miller. Major elemental cycling in a high elevation Adirondack forest: Patterns and changes, 1986 - 1996. Ecological Applications 9: 958-967. (1999)
[3] Pandey, J. & U. Pandey. Microbial processes at land-water interface and cross-domain causal relationship as influenced by atmospheric deposition of pollutants in three freshwater lakes in India. Lakes & Reservoirs: Research and Management 13: 71-84. (2009)
[4] Thornton, G. J. P. & N.B. Dise. The influence of catchment characteristics, agricultural activities and atmospheric deposition on the chemistry of small streams in the English Lake District. The Science of the Total Environment 216: 63-75. (1998)
[5] Schwartz, J. Air pollution and daily mortality: A review and meta - analysis. Environmental Research 64: 26-35. (1994)
[6] Jain, C. K. A hydrochemical study of a mountainous watershed: The Ganga, India. Water Research 36: 1262-1274. (2002)
[7] Singh, M. & A.K. Singh. Bibliography of environmental studies in natural characteristics and anthropogenic influences on Ganga River. Environmental Monitoring and Assessment 129: 421-432. (2007)
[8] Vanloon, G.W. and S.J. Duffy, The Hydrosphere. In: Environmental Chemistry: A Global Perspective. 2nd Edn. New York: Oxford University Press, pp: 197-211. (2005)
[9] McMurry, J. and R.C. Fay, Hydrogen, Oxygen and Water. In: McMurry Fay Chemistry. K.P. Hamann, (Ed.). 4th Edn. New Jersey: Pearson Education, pp: 575-599. (2004)
[10] Mendie, U., The Nature of Water. In: The Theory and Practice of Clean Water Production for Domestic and Industrial Use. Lagos: Lacto-Medals Publishers, pp: 1-21. (2005)
[11] WHO, Water for Pharmaceutical Use. In: Quality Assurance of Pharmaceuticals: A Compendium of Guidelines and Related Materials. 2nd Updated Edn. World Health Organisation, Geneva, 2: 170-187. (2007)
[12] Vodela, J.K., J.A. Renden, S.D. Lenz, W.H. Mchel Henney and B.W. Kemppainen, Drinking water contaminants. Poult. Sci., 76: 1474-1492. (1997)
[13] Marcovecchio, J.E., S.E. Botte and R.H. Freije, Heavy Metals, Major Metals, Trace Elements. In: Handbook of Water Analysis. L.M. Nollet, (Ed.). 2nd Edn. London: CRC Press, pp: 275-311. (2007)
[14] Adepoju-Bello, A.A., O.O. Ojomolade, G.A. Ayoola and H.A.B. Coker, Quantitative analysis of some toxic metals in domestic water obtained from Lagos metropolis. The Nig. J. Pharm. 42(1): 57-60. (2009)
[15] Adepoju-Bello, A.A. and O.M. Alabi, Heavy metals: A review. The Nig. J. Pharm., 37: 41-45. (2005)
[16] M.A. Momodu and C.A. Anyakora, Heavy Metal Contamination of Ground Water: The Surulere Case Study, Research Journal Environmental and Earth Sciences 2(1): 39-43. (2010)
[17] Adeyemi, O., O.B. Oloyede and A.T. Oladiji, Physicochemical and microbial characteristics of Leachate contaminated ground water. Asian J. Biochem., 2(5): 343-348. (2007)
[18] Vodela, J.K., J.A. Renden, S.D. Lenz, W.H. Mchel Henney and B.W. Kemppainen, Drinking water contaminants. Poult. Sci., 76: 1474-1492. (1997)
[19] Igwilo, I.O., O.J. Afonne, U.J. Maduabuchi and O.E. Orisakwe, Toxicological study of the Anam River in Otuocha, Anambra State, Nigeria. Arch. Environ. Occup. Health, 61(5): 205-208. (2006)
[20] http://mirzapur.nic.in/Geography.htm

