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Full Length Research Paper

Study of levels of heavy metals in the river waters of regions in and around Pune City, Maharashtra, India

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ABSTRACT

Heavy metal contamination of the Mula Mutha and Pavana Rivers of Pune city during the month of January 2015 was assessed through quantitative analysis. The samples were analyzed for different heavy metals (Cd, Co, Cr, Cu, Ni, Pb and Zn). This study was conducted to determine the quality of run-off water which is used for drinking in the study area. A total of nine water samples were collected from the river sites. The samples were analyzed for their pH, electrical conductivity, total dissolved solids and different trace metal contents. The mean concentrations of Cd and Pb obtained were respectively 0.039 and 0.107 mg/L which were higher than the permissible limits declared by World Health Organization (WHO), while mean nickel concentration was slightly at higher end than the permissible limit of WHO. Results showed the presence of Cd, Ni, Pb and Cu in the water samples. It is further inferred from the results that the concentration of Cr, Mn, Zn and Mo is within the allowed WHO limits in drinking water.

Keywords: Run off water, quantitative analysis, water analysis, Mula river, Mutha river, Pavana river, Bhima river.

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INTRODUCTION

Pune is situated 560 m above sea level on the Deccan Plateau at the confluence of the Mula and Mutha rivers of India. It is situated on the leeward side of Sahayadri mountain range which forms a barrier from Arabian Sea. Pune is the 7th largest metropolis in India, the second largest in the state of Maharashtra after Mumbai and the largest in the Western Ghats.

Central Pune is located at the confluence of Mula and Mutha River. The Pavana and Indrayani Rivers, tributaries of Bhima River, traverse the northwestern out skirts of Metropolitan Pune. Pune is known for educational facilities and prosperity. Pune ranked as a Gamma global city. Pune has a tropical wet and dry climate with average temperatures between 20 and 28°C. Pune experiences 3 seasons, that is, summer, Monsoon and Mild Autumn. This article focuses on the heavy metal concentrations in surface waters of Pune city and discusses its effect on the water quality.

Though some metals like Cu, Fe, Mn, Ni, Zn are essential to life, many other metals like Cd, Cr, Pb have very dangerous effects if present beyond a certain limit (Jain, 1978; Shrivastav, 2001; Duruibe et al., 2007; WHO, 1971). The contamination of water is directly related to the degree of contamination of our environment. Rainwater collects impurities while passing through the air. Streams and rivers accumulate impurities from surface runoff and through the discharge of sewage and industrial effluents; these are carried further to lakes or reservoirs that supply our drinking water. All of the chemicals generated by man will eventually end up in our water supplies. These dangerous products from industry, agriculture and other human activities enter the rivers, lakes and underground water, and can contaminate water.

The aim of this study is to determine the relationship between the heavy metal concentration in water and its impact on the water quality of Pune River in Pune City. Atomic absorption spectroscopy is used as the

Figure 1. Pune Geographic MAP.

characterization technique for the conducted study. In the present research work, a total of nine water samples from Pune city, Pune river, Mula, Mutha and Pavana rivers were collected for the assessment of the heavy metal concentration during the month of January 2015.

MATERIALS AND METHODS

Study area

Heavy metal contaminations of the Mula, Mutha and Pavana Rivers of Pune city (18.5203°N, 73.8567°E) during month of January 2015 were assessed using Atomic Absorption Spectrophotometer. The samples were analyzed for different heavy metals (Cd, Co, Cr, Cu, Ni, Pb and Zn). This study was conducted to determine the quality of run-off water which is used in the study area. (Figure 1)

Sampling of water

Water samples were collected from nine different sites of Pune City. The descriptions of sampling sites are given in Table 1. The water samples were collected from depths of 30 cm below the surface and kept in 1 L prewashed polythene containers. The water samples were then kept in a refrigerator at ~4°C prior to analysis.

Metal analysis

Each acid digested water sample of 100 cm^3 was taken in the beaker and the beaker was kept in an oven at 70°C to reduce the volume of the water up to 50 cm^3. The concentration of Cd, Co, Cr, Cu, Ni, Pb and Zn in each water sample were determined by using an Atomic Absorption Spectrometer (AAS: AAS: LABINDIA: AA-7000) AAS required an acid digestion step prior to analysis by treating the samples with concentrated HNO_3. Digestion of samples is performed essentially as described in standard method in American Public Health Association (APHA, 1989). The instrument settings were determined from the recommendations in the instruction manual (IO).

RESULTS AND DISCUSSION

Heavy metals in the water samples

The values of heavy metal contents present in the water samples are given in Table 2.

The variation of the concentration of heavy metals in nine different samples of water collected from Mula, Mutha and Pavana are shown in Figures 2 to 5. Of all heavy metals analyzed in the water samples collected

Table 1. Description of sample collection points.

Sample	Site description
S1	Panshet Dam – Mutha River
S2	Upstream of Khadakwasla Dam – Mutha River
S3	Downstream of Khadakwasla Dam
S4	Mulshi Dam – Mula River
S5	Paud – Mula River
S6	Pavana Dam – Pavana River
S7	Bevad Ovhal – Pavana River
S8	Aundh – Mula River
S9	Yerwada – Pune City

Table 2. Concentration of heavy metals in water from rivers of Mula, Mutha and Pavana.

Element	S1	S2	S3	S4	S5	S6	S7	S8	S9	WHO standards (mg/L)	WHO max permissible limits (mg/L)
Cd	0.0445	0.0395	0.0134	0.0311	0.1033	0.0361	0.0395	0.0411	0.042	0.003	0.005
Co	0.0135	0.0135	0.0202	0.0303	0.0359	0.0281	0.0348	0.0269	0.0258	0.01	0.01
Cr	0.0229	0.0242	0.0498	0.0229	0.0323	0.0377	0.0323	0.0431	0.0296	0.05	0.05
Cu	0.0006	0.0039	0.0213	0.009	0.0039	0.0123	0.0239	0.0884	0.0497	0.05	0.05
Ni	0.0038	0.0178	0.0241	0.0533	0.0127	0.033	0.0305	0.0432	0.0432	0.02	0.02
Pb	0.166	0.1026	0.0578	0.1063	0.0896	0.1381	0.01847	0.2071	0.0877	0.01	0.05
Zn	0.0756	0.0807	0.0057	0.0069	0.029	0.0296	0.012	0.2061	0.2074	3	5

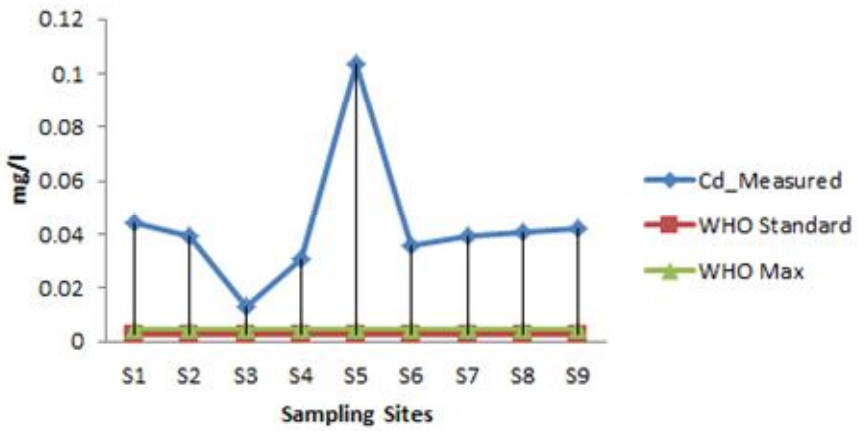

Figure 2. Cadmium levels in different water samples.

from various sites, the mean concentration of Co, Cd and Pb were estimated to be 0.028, 0.039 and 0.108 respectively and so were in excess as compared with the permissible limit declared by World Health Organization (WHO). Mean concentration of Ni was also estimated to be slightly on the higher end than the permissible limit declared by WHO. However, the Cr and Zn concentrations in water samples were estimated to be 0.032 and 0.072 and were very much in the permissible limits declared by WHO.

According to the guidelines of WHO the maximum concentration of Cd in drinking water should be 0.005 mg/L. All the samples from S1 to S9 had concentrations exceeding the maximum concentration levels given by WHO (1983). Among all other samples, S5 (Paud – Mula river) has highest value of Cd, that is, 0.103 mg/L while the least Cd concentration was 0.013. Pb was present well above the allowable limit (0.91 mg/L) in all the nine water samples collected from the sample sites and recorded the range of 0.058 to 0.207 mg/L (Figure 4).

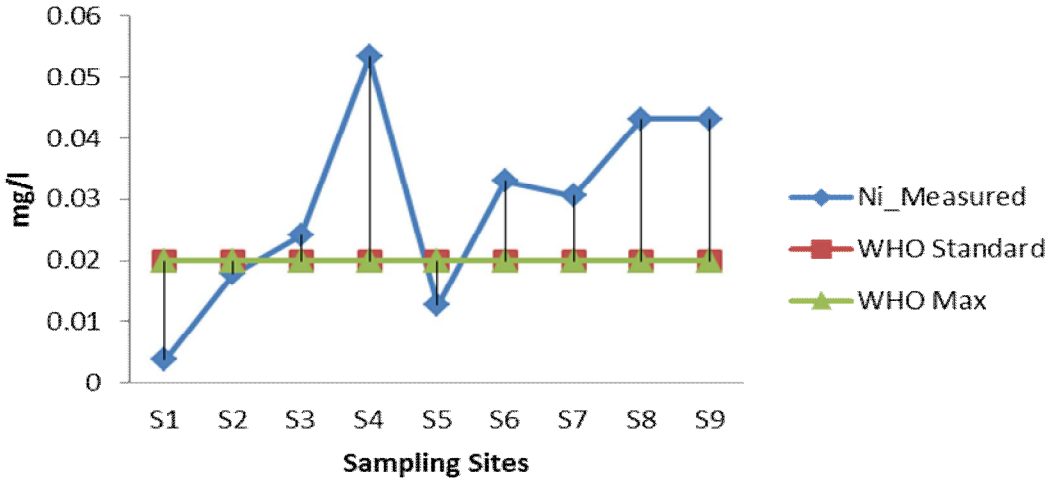

Figure 3. Nickel levels in different water samples.

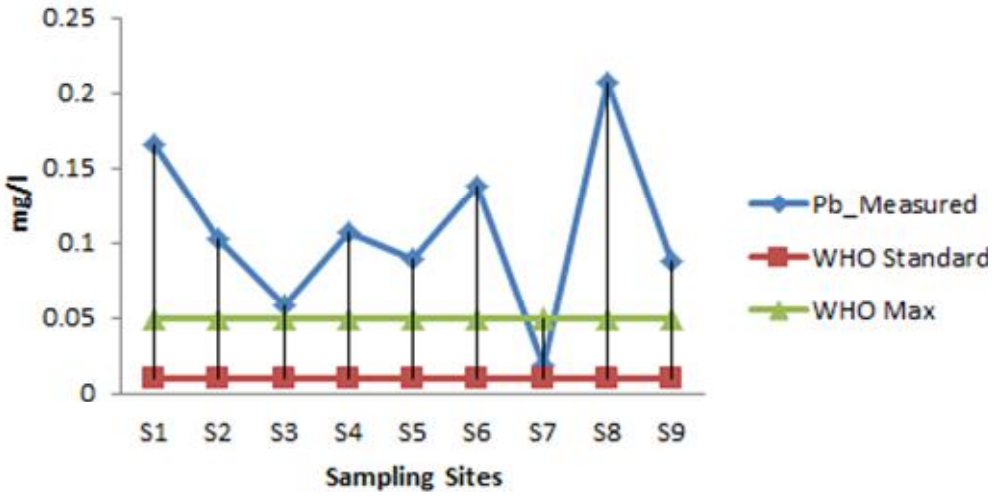

Figure 4. Lead levels in the water samples, S1 to S9.

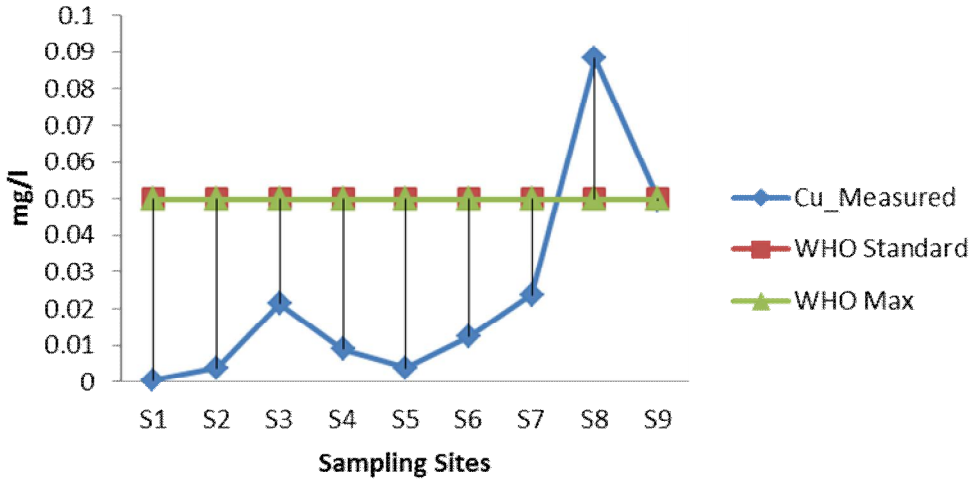

Figure 5. Copper levels in different water samples.

The results of the of nine water samples indicated that the concentration of Pb in S8 was four times while S1, S2, S4 and S6 were almost double the permissible limit of Pb in drinking water as recommended by WHO (0.01 mg/L).

The concentration of Ni in the water samples collected has the range 0.0533 to 0.0127 mg/L while the permissible limit for drinking water is 0.02 mg/L. The concentration of Ni was the highest in the sample coded S4 compared to its Ni levels in S1, S2, S3 and S5 water samples, which were very much under permissible limits. Remaining samples S6, S7, S8 and S9 were exceeding the permissible limits given by WHO guideline values for drinking water.

The concentration of Cu for the tested water samples ranges from 0.0884 to 0.0006 mg/L and the permissible limit for drinking water is 0.05 mg/L. In S8 the concentration of Cu is highest and in the remaining samples its levels are in the permissible limits given by WHO.

The collection sites S2 and S3 are very near to the PMC water supply plant of Pune city and the villages of surrounding areas. Samples S8 and S4 are also utilized by the people of Pune directly. In view of the above, the analysis of heavy metal concentrations in the sample sites suggests that the metal concentrations of Pb and Cd are alarmingly high and measures should be taken to reduce their concentrations in the waters of these areas. This is very important since there are potential health risks associated with the excessive concentrations of these heavy metals.

Location wise analysis of heavy metals

1. S1 – Panshet Dam – Mutha River sample had cadmium and Lead concentration higher than permissible limit declared by WHO.
2. S2 – upstream of Khadakwasla Dam – Mutha river sample had Cd and Lead in higher concentrations than permissible limits declared by WHO [Cd (0.003 mg/L), Pb (0.01 mg/L)].
3. S3 – Downstream of Khadakwasla Dam – Mutha river ample had Cd at higher concentrations and Ni at slightly higher concentration than permissible limit declared by WHO [Cd (0.003 mg/L), Ni (0.02 mg/L)].
4. S4 – Mulshi Dam – Mula river, Sample had cadmium (0.0311 mg/L), Nickel (0.0533 mg/L) and Lead (0.1063 mg/L) at higher concentrations than permissible limit declared by WHO [Cd (0.003 mg/L), Ni (0.02 mg/L), Pb (0.01 mg/L)].
5. S5 – Paud – Mula River, Sample had Cd (0.1033 mg/L) and Pb (0.003 mg/L) at higher concentrations than permissible limit declared by WHO [Cd (0.003 mg/L), Pb (0.01 mg/L)]
6. S6 - Pavana Dam – Pavana – river – Sample had Cd (0.036 mg/L), Pb (0.1381 mg/L) and Ni (0.033 mg/L) at higher concentration than permissible limit declared by WHO [Cd (0.003 mg/L), Ni (0.02 mg/L), Pb (0.01 mg/L)].
7. S7 – Bevad Ovha – Pavana River – Sample had Cd (0.0395 mg/L), Pb (0.1847 mg/L) and Ni (0.0305 mg/L) at higher concentrations than permissible limit declared by WHO [Cd (0.003 mg/L), Ni (0.02 mg/L), Pb (0.01 mg/L)].
8. S8 – Aundh – Mula river sample had Cd (0.0411 mg/L), Cu (0.0884 mg/L) , Ni (0.0432 mg/L) and Pb (0.207 mg/L) at higher concentrations than permissible limit declared by WHO.
9. S9 – Yerwada Pune Sample had Cd (0.042 mg/L), Ni (0.0432 mg/L) and Pb (0.0877 mg/L) at higher concentrations than WHO values.

CONCLUSION

Quantitative analysis of heavy metals was conducted for the samples of river waters in the regions in and around Pune city, India. The studies reveal that different sampling sites have heavy metals in different concentrations. The concentration levels of certain heavy metals are alarmingly high in all the areas considered for sampling. The levels of Cd in all the sites are apparently more than the permissible limits set by WHO. The levels of Pb are equally bothering in view of their toxicity towards biological systems. Ni in few areas and Cu in one area are also on the higher side with respect to the acceptable global standards. Keeping in view the health risks involved due to the high levels of metals when they enter the human metabolism, measures should be taken to reduce these levels in the potable waters to mitigate the imminent health risks.

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