Health Hazards Associated With Heavy Metal Contamination With Reference To Narmada River At Nimar Region Of Madhya Pradesh

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ABSTRACT

In the present work the Water samples were collected monthly from October 2010 to August 2011 in triplicate, totaling 165 water samples. The five sampling locations were: the Omkareshwar Ghat (OG), Maheshwar Ghat (MG1); Mandleshwar Ghat (MG2); Navda Todi (NT), and Punasa Dam (PD). The levels of As, Be, Ca, Cd, Co, Cu, Cr, Fe, Li, Mg, Mn, Mo, Ni, Pb, Sb, Se, Sr, Ti, Ta, V and Zn were measured by using atomic absorption spectroscopy. In addition, temperature, pH, electrical conductivity and total and fecal coliformes were determined. The statistical analysis considered a factorial treatment design; where factor A was the location point and factor B was sampling date. In addition, a multivariate technique looking for principal components was performed. Overall, the results confirmed that this stretch of the Narmada River is contaminated with heavy metals and other contaminants that might affect human health as well as the health of the ecosystem.

Keywords: metals, metalloids, water quality

INTRODUCTION

The concern for water resources containing contaminants, such as heavy metals and toxic metalloids, that pose a threat to health, has increased worldwide. The presence of metals in water results from two independent factors. The first involving the weathering of soils and rocks with its products being transported by air and water, and the second involving a variety of anthropogenic activities that have created a societal health risk in rivers that receive a substantial amount of waste, as it is the case of the Narmada. The hypothesis of this study was that the Narmada has not escaped the effects of pollution, and that in synergy with the recurrent droughts that affect the state, its polluted condition has severely increased the problem. In order to quantify the severity of the pollution, metal and metalloid concentrations as well as other quality parameters such as coliforms were determined. The results obtained here will be beneficial for preventive as well as correctional schemes to the inhabitants of the area and in the design of a basin management program towards recovery of this river's ecosystem. Furthermore, these results will be important and necessary to be included in ongoing health-related programs in the East and West Nimar parts of Madhya Pradesh.

MATERIALS AND METHODS

The study area is located within the East and West Nimar Parts of Madhya Pradesh, Five sites along the part of the Narmada River were selected for sample collection. Water samples were collected monthly by triplicate, from October 2010 to August 2011. Therefore, a total of 165 water samples were collected. Point 1 was Omkareshwar Ghat (Latitude– 21° 14'25" N and Longitude– 76° 09'45"E). This point will be referred to as (OG). Point 2 was Maheshwar Ghat (Latitude–22° 11' N and longitude 75° 37' E) This point will be referred as (MG1) Sampling point 3 was Mandleshwar Ghat (longitude- E 76° 15' and latitude N21^{o}).This point will be referred as (MG2). Point 4 was Navda Todi (longitude E 76° 20' and latitude N 22 ^{o} 33'). This point will be referred as (NT). Point 5 was Punasa Dam . Latitude-22 ^{o} 17'00 and Longitude-76 ^{o} 28'00". This point will be referred as (PD)[1].

The temperature was determined by using a mercury thermometer with a range of -10° C to 100° C. The electrical conductivity (EC) was determined by using a digital conductivity meter with a range of 0.01-19.99 dSm^{-1}. The pH was determined by using a digital pH meter having standard glass electrode with a range of -1.0 to 15-0. Water samples were collected in sterilized containers, preserved in a cool place (about 4° C) and transported to the laboratory of the College for further analysis. The water samples were analyzed according to APHA procedures [2].

The evaluated metals were Arsenic (As), Beryllium(Be), Calcium (Ca), Cadmium (Cd), Cobalt (Co), Cupper (Cu), Chromium (Cr), Iron (Fe), Lithium (Li), Magnesium (Mg), Manganese (Mn), Molybdenum (Mo), Nickel (Ni), Lead (Pb), Antimony (Sb), Selenium (Se), Strontium (Sr),Titanium (Ti), Tantalum (Ta), Vanadium (Va) and Zinc (Zn). The determination of metals was done using an Atomic absorption spectrophotometer[3]. The statistical analysis for each element included a factorial treatment design; where factor A was the location point and factor B was sampling date. The differences were noted using a 0.05 significance level for main effects as well as for the interaction effect. Finally, a Multiple Analysis of Variance (MANOVA) was performed using 15 elements from which principal components were identified.

RESULTS AND DISCUSSION

The average temperature was 24° C±3.85. This parameter varied with sampling location, time of collection and season of the year.

The pH values detected in water of the Narmada River were found to be in the permissible range of 6.5 to 8.5. The average was 7.69 ± (0.405) indicating a slightly alkaline water.

With respect to EC, it can be noted that values increased from only 0.29 dSm^{-1} at the OG site to 1.62 dSm^{-1} at the LJ site. The average EC was 1.33 d Sm$^{-1.}$

The results for As in this study showed variability for both sampling location and sampling month. In Figure 1, it is evident that the location OG was less contaminated with 0.07 mg L-1 in comparison with the other points; the maximum amount was detected in PD with 0.16 mg L^{-1}. Furthermore, most As concentrations are higher than the values recommended in Indian and International norms for drinking water. In Addition, some concentrations were also higher than that established in Indian norms for water used in agriculture (0.10 mg L^{-1}). The findings reported here, must be an alert to health agencies in Nimar communities because this element has been associated to development of Leukemia, abnormalities in children cancer and with various other diseases.

The Analysis of Variance showed significant differences for Be concentration due to sampling point, sampling month as well as the interaction (Figure 2).

Be is not considered an essential element for human and, in fact, is toxic and responsible for the chronic beryllium disease caused by beryllium exposure. In this study, the average Be concentration in some locations and sampling months was higher than the limits for drinking water (0.00007 mg L^{-1}. The lowest Be concentration was reported in OG with 0.011 mg L-1 while the highest was noted in PD with 0.014 mg L^{-1}. The mean of Be was higher in June and July with 0.035 mg L^{-1} while the lowest average value was in November with 0.002 mg L^{-1} and December with 0.0006mg L^{-1}.

With respect to the element Ca, there were statistical differences in concentration due to sampling location, sampling month as well as for the interaction (Figure 3). The lower Ca concentration was observed in the upper part of the river (OG) with a mean of 23.21 mg L^{-1} and as the water flows down, the Ca concentration increased to reach an average of 120.23 mg L-1 in NT. With respect to sampling date, it was noted that maximum amount of Ca was observed in rainy months, which also correspond to the period of time when fields are being irrigated, reaching a high in June with 137.50 mg L-1 compared to the 59.74mg L-1 obtained in November.

The Cd concentration was different just for sampling month and no statistical differences were noted for sampling location neither for the interaction. The maximum level of Cd was observed in March with an average of 0.014 mg L-1 while the concentration for the rest of the months was quite homogeneous.

The Analysis of Variance detected statistical differences in Co concentration for sampling month as well as for the interaction; nevertheless, not differences were noted for sampling locations. Figure 4 shows the interaction plot for this element, showing an average mean

concentration in a range of 0.002 to 0.003 ppm in all locations. Maximum Co levels were obtained in November and December with values of 0.007 mg L^{-1} and 0.008 mg L^{-1}, respectively. The Cu concentration was statistical different just for sampling months. The maximum level of Cu was obtained in July with 0.20 mg L^{-1}. In fact, higher concentration of this element was observed during the irrigation-rainy season` months while the lower concentration persisted for the rest of the months.

The element Cr was different for sampling location, sampling month and the interaction (Figure 5). The lowest Cr concentration was obtained in location OG with 0.06 mgL^{-1}, followed for a level of 0.07 mg L^{-1} in PD, MG2 and MG1, while the high level was noted in PD with 0.08 mg L^{-1}. It is important to point out that the concentration of Cr in water of the Narmada River in some months and in all locations exceeded the standards established in Indian norm for drinking water (0.05 mg L^{-1}). For instance, Cr concentration in June was 0.160 mg L^{-1}, in July 0.192mg L^{-1} and in August 0.212 mg L^{-1}.

The Fe concentration was different with respect to sampling location, sampling month and the interaction (Figure 6). The maximum amount of Fe was found in PD with 1.09 mg L^{-1}. With respect to sampling month, the high concentration was detected in July with 1.80 mg L^{-1}. These values exceeded the limited value established in the Indian Norm (0.3 mg L^{-1}).

Li differences were observed as a function of sampling location, sampling month and the interaction (Figure 7). It can be seen from this figure that the minimum Li concentration with 0.02 mg L^{-1} was detected in OG while in the location PD the concentration was as high as 0.31 mg L^{-1}. According to the significant difference in Li concentration between the upper location and the lowest location, it can be hypothesized that this difference was caused by anthropogenic effects, possibly an effect of irrigation. Considering sampling months, the maximum levels were detected in March with 0.331 mg L^{-1} and June with 0.307mg L^{-1}. The Li amounts observed in this study are higher than results of other studies in different environments. The most important aspect to point out is the potential toxic effects of this element in some organisms that live in water of the Narmada River, when is analyzed

that levels of 0.4 mg L^{-1} could be toxic to some insect larvae.

The Mg levels were different for sampling location, sampling month and the interaction as based on the analysis of variance. It is evident from Figure 8 that the lowest Mg concentration occurred in OG with 5.82 mg L^{-1}in comparison with the rest of the sampling locations whose values were 21.59 mg L^{-1} in MG1, 27.43 mg L^{-1} in MG2, 28.59 mg L^{-1} in MG1 and 26.84 mg L^{-1} in PD. Considering the sampling month, the maximum levels of Mg were detected in June with 33.08 mg L^{-1}.

There were no differences for Mn concentration for the factor of sampling location neither the interaction; but significant differences were noted for sampling month. The maximum levels were noted during winter time with 4.36 mg L^{-1} in December and 4.62 mg L^{-1} in January.

The Mo concentration was different for sampling location, sampling month and the interaction (Figure 9). It can be noted that in OG was the lowest Mo concentration with 0.006 mg L^{-1} and in the rest of the locations the amount of Mo was similar. Differences for sampling month and the interaction were noted for Ni; nevertheless, no differences were observed for sampling location. Figure 11 shows that the lowest amount of Ni was detected in OG with 0.16 mg L^{-1} followed by 0.21mg L^{-1} in MG2. During June the highest Ni concentration was0.30 mg L^{-1} followed by July with 0.23 mg L^{-1}.

Significant differences were noted for the element Sr, considering both factors as well as the interaction. It was evident that the minimum amount of Sr was detected in OG with 0.33 mg L^{-1} and in the way that the water flows down the river, the amount of this element increased to 2.25 mg L^{-1} in MG2 and 2.18 mg L^{-1} in PD. Maximum levels in sampling months were found for May with 2.07 mg L^{-1} and June with 2.44 mg L^{-1}.

The lowest concentration was observed in OG with 0.015mg L^{-1} and it can also be seen that the lowest concentration occurs in winter time and the higher level during the rainy season with 0.06 mg L^{-1} in August. The elements Pb, Sb, Se, Ti, Ta, Zn were not affected by sampling month and sampling locations and no regular trend was noted for these elements.

The results of the multivariate analysis associated to locations showed positive values in the component 1 for Mg (0.447 mg L-1), Sr (0.444

mg L-1), Ca(0.432 mg L-1) and Li (0.417 mg L-1) as well as negative values for As (0.162 mg L-1) and Fe (0.102 mg L-1). With respect to component 2, there were positive values for V(0.537 mg L-1), Be (0.488 mg L-1), Fe (0.377 mg L-1) and Ni (0.313 mg L-1) as well as negative values for Li (0.135mg L-1) and Sr (0.101 mg L-1). It was evident a predominant aggregation of OG location in the positive quadrant of component 2 and negative of component 1,meaning that, in this particular location, there was mainly the presence of As, Sr, Fe and Li. The rest of the locations did not present a tendency of aggregation. The analysis of the component 1 and component 2 associated to sampling months showed that December, January, March and April had a tendency for aggregation in the negative quadrant of the component 1, meaning that in those months, there was presence of Va, Ni, Be, Fe y As. This results were verified using a multi variance analysis (MANOVA)in order to obtain statistical differences for sampling month effect (P<0.05), location (P<0.05) and for the interaction (P<0.05).

With respect to the evaluation of microorganisms in water of the Narmada River, it was found that fecal coliform counts were the higher during July (11,000cfu/100 ml) and August samples (1,868 cfu/100 ml) in location PD. The number of fecal coliforms increased downstream and they exceeded the Mexican Norm values of 1,000 cfu in 100 ml. With respect to total coliform counts, they were similar to the trend of fecal coliform; hence, highest values were obtained in July (43,000 cfu) and August samples (4,880 cfu) in location PD.

Conclusions

The Narmada River shows a significant degree of contamination in its water. This level of contamination is not permanent in all locations and might be associated with season of the year, drought events and due to anthropogenic activities. The high As concentration measured in this study raises a red flag to the health of communities settled along the Narmada River.

References

1. Madhya Pradesh District Gazetteers; 1969-1970, P.No. 201.
2. Lark B S, Mahajan R K and Walia T P S, *Indian J Environ Health*, 2002, **44**, 164–167.
3. Clesceri L S, Standard methods for the examination of water and waste water. In Collection and Preservation of Samples and Metals (Ed., Arnold, E., Greenbergy and Eaton, A. D.), APHA, AWWA, WEF, Washington, DC, 1998, **35,** 3-21.

Figure 1: Concentration of As in water considering five location points and 11 consecutive months of sampling (date 1 corresponds to October 2010)
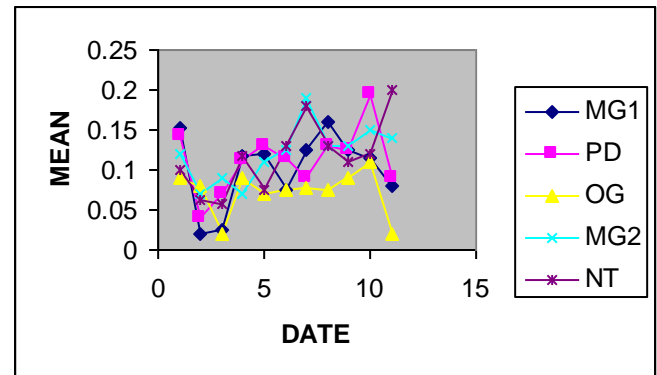

Figure 2: Interaction plot for Be in water considering five location points and 11 consecutive months of sampling(month 1 corresponds to October 2010)
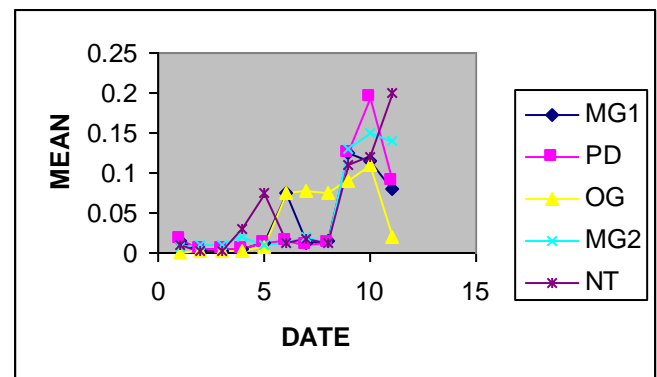

Figure 3: Interaction plot for Ca in water considering fivelocation points and 11 consecutive months of sampling(month 1 corresponds to October 2010).
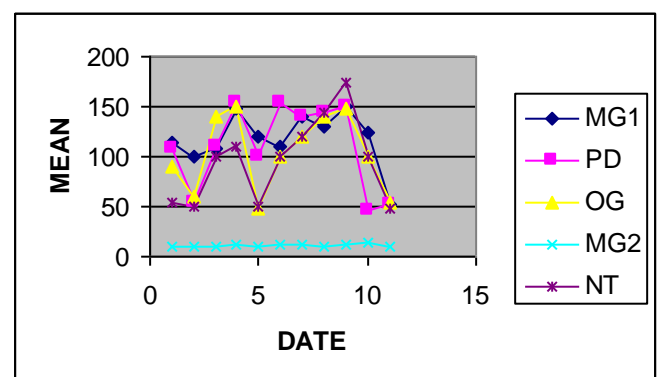
Figure 4: Interaction plot for Co in water considering five location points and 11 consecutive months of sampling(month 1 corresponds to October 2010)
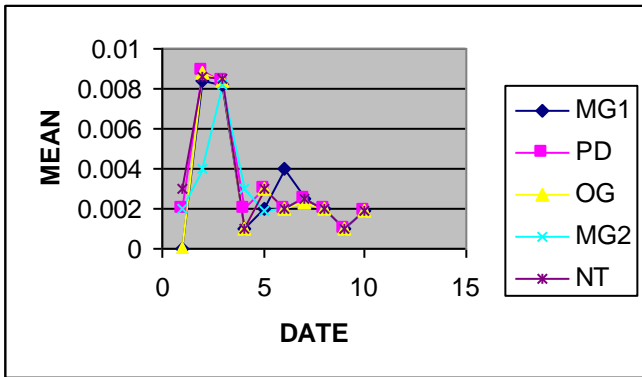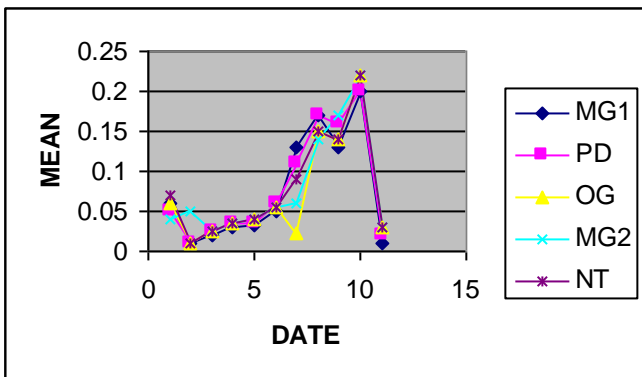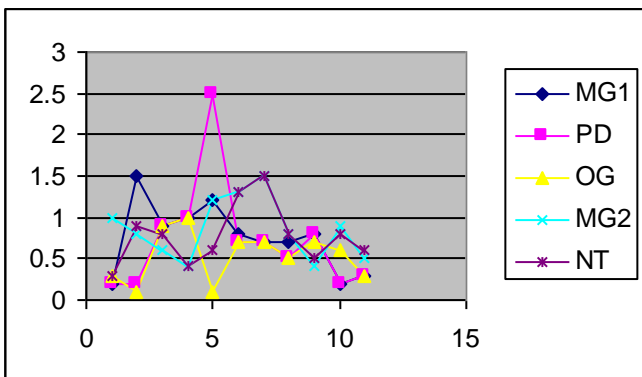

Figure 5: Interaction plot for Cr in water considering five location points and 11 consecutive months of sampling (month 1 corresponds to October 2010)

Figure 6: Interaction plot for Fe in water considering five location points and 11 consecutive months of sampling (month 1 corresponds to October 2010)

Figure 7: Interaction plot for Li in water considering five location points and 11 consecutive months of sampling (month 1 corresponds to October 2010
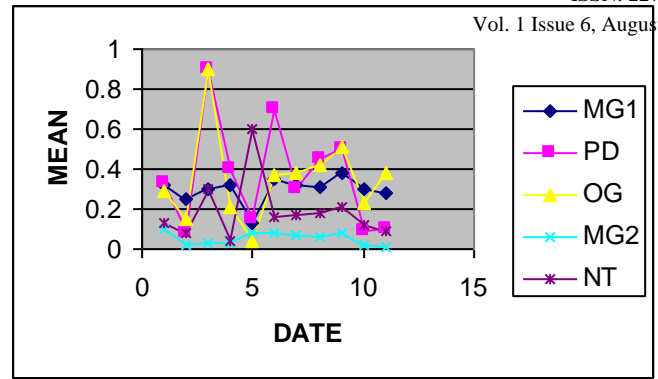

Figure 8: Interaction plot for Mg in water considering five location points and 11 consecutive months of sampling (month 1 corresponds to October 2010)
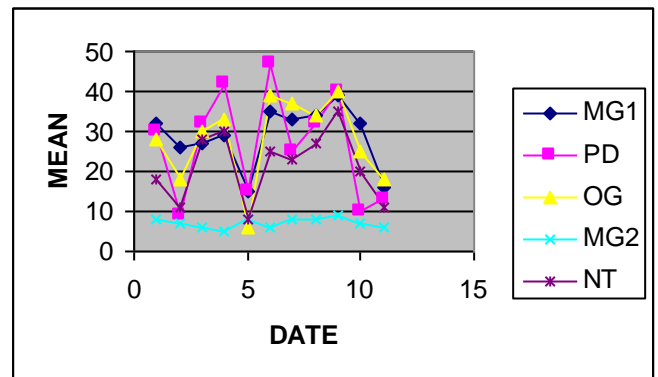

Figure 9: Interaction plot for Mo in five sampling locations and 11 consecutive months of sampling (month 1 corresponds to October 2010)