

ASSESSMENT OF QUALITY OF MAHANADI RIVER WATER FOR IRRIGATION AND DOMESTIC PURPOSES

DR. P.C. MOHANTY

Kendriya Vidyalaya, Charbatia (Odisha), India

DR. S. PATNAIK

S.B.W. College, Cuttack (Odisha), India

AND

P.K. MISRA

Ex-Department of Chemistry, Ravenshaw College, Cuttack (Odisha), India

RECEIVED : 20 July, 2015

The level of occurrence of some metals like iron (Fe), zinc (Zn), lead (Pb), nickel (Ni), cobalt (Co), cadmium (Cd), arsenic (As) and mercury (Hg) were estimated in water of the river Mahanadi. The average levels of metals followed the order $Zn > Pb > Cd > Ni > Co > As > Hg$. Present study revealed that the dissolved constituents of Fe, Pb, Cd and Zn were above the ranges of unpolluted water indicating their contamination throughout the season in cases of Pb, Fe and Zn and occasional for Cd and Cr. The metals Ni, Co and As almost remained in natural level while Hg was always below the detection limit of 0.001 ppm. The water area between Cuttack and Paradeep each could be identified as the probable area of contamination of these metals.

INTRODUCTION

Nature always maintains a safe condition of its environment for the sustenance of biological life by providing tolerable limit of essential elements and by dispersing enriched level of undesirable substances through some active agents. Hydrological cycle is the best example for one of these agents, which evaporate pure water from the ocean, distribute throughout all spheres, preserved in ground water for safe drinking and the remaining is used for washing of the environment. After being contaminated the water is again returned to the ocean, a natural stabilization pond through the rivers, streams, nullas etc. and undergoes treatment for further use. Thus the composition of water in a logic system like river largely reflects the phases through which it flows and differs from each other. The sources of any element in river water originate from the dissolution of air borne suspended particles during precipitation, weathering of soil minerals in course of flowing and from anthropogenic activities in and around the river system. However the degree of occurrence depends on the extent of contamination as well as the self-rectification capability of the respective system. Undesirable events can happen only when the dynamic equilibrium of the system is hampered by the introduction of excessive amount of contamination. Accordingly the degree of occurrence of elements in the environment could highlight the possible state of the system and the effects. With this idea some trace metals including toxic were estimated in water of the most important river the Mahanadi during the year 2016 covering the areas of which are prone

to be contaminated by these metals due to various anthropogenic activities on both banks of this river.

Most of the Mahanadi river waters are useful for both irrigation purposes and domestic use in Odisha. The available information gives the impression that no attempts were made for the assessment of these waters. In the present studies the author attempted to collect data on the distribution of various major ions. Earlier researches reveal that the information on the calcium, magnesium, sodium and potassium will be highly helpful in deciding the fate of the waters used in the irrigation purposes. Monthly samples were collected over a period of six months and they were analysed for the parameters like calcium, magnesium fluoride, sodium and potassium. The Sodium Absorption Ratio (SAR) and Exchangeable Sodium Percentage (ESP) were calculated. It has been found from the values of both SAR and ESP that the Mahanadi river waters in Odisha are quite suitable for the irrigation purpose.

The River Mahanadi is the largest flowing peninsular river in Odisha. It rises in the Chhotanagpur of M.P. and flows south-east for about 1400 km to Paradeep point in Odisha where it conflues with the Bay of Bengal. The river drains over an area of 2,59,000 km. The total annual discharge is estimated at 62,780 million m³.

Soil in the Mahanadi river basin consists of black, red, laterite, alluvium, mixed soils, saline and alkaline soils. Irrigation was practiced in the basin from the earliest times by tanks and diversions. The gross shown area is 10 million ha forming 60% of the cultivable area. The percentage of irrigation is twenty five.

Methodology

The information on Sodium Absorption Ratio (SAR);

$$SAR = \frac{Na^+}{\left[\sqrt{(Ca^{2+} + Mg^{2+})/2} \right]}$$

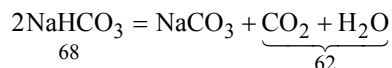
is the most important factor in examining the utility of the irrigation waters with regard to the alkali hazard/depletion, which in turn explain the tilth and permeability. Another important parameter useful in deciding the fate of the waters for the irrigation purposes is Exchangeable Sodium

$$\text{Percentage (ESP) ESP} = \frac{100(-0.0126 + 0.01475 \text{ SAR})}{1 + (-0.0126.0.01475 \text{ SAR})}$$

while the ESP is mostly dependent on the pH value. The influence of SAR. ESP and their relationship with pH and the interpretation of the values of the above parameters were described in earlier literature. (2.3)

Iron is estimated colorimetrically using o-phenanthroline. Chloride is estimated volumetrically using silver nitrate solution. Presence of sulphate is estimated by turbidimethic method [4]. Using BaCl₂ solution, and total and dissolved sulphide by colourimetric method. Using N.N-Dimethyl-p-phenylenediamine [4]. Total soluble salts were determined by taking 100 ml. of water (after filtration) to a previously weighed porcelain dish. It was evaporated to dryness on a water bath followed by drying in an oven at 100°C. It was cooled and weighed. The weight of residue represented the total solid in 100 ml. of water sample. So total solid in 1000 litres was found out to express it in ppm.

Since on heating the bicarbonates loose CO₂ and H₂O the weight of residue is less. For every gram of bicarbonate in water, the loss is 0.369 gm as per the equation.



So loss per gramme of $\text{NaHCO}_3 = 62/168 = 0.369$.

So correction factor = weight of bicarbonate $\times 0.369$

EXPERIMENTAL

Six stations were located at equidistant places in the four districts of Odisha over a distance of 400 km from the shore to the inner side. They are 1. Cuttack, 2. Banki, 3. Athgarh, 4. Sambalpur, and 5. Narsinghpur and 6. Paradeep. All the stations have been selected on the local importance especially in view of the agricultural and industrial run off as the same waters serve the cause of both domestic and irrigational purposes in this area.

Monthly samples were collected from the stations with equal intervals of time from January to June 2016 during day time between 10 am and 3 pm at a distance of 10 ft. inside the river from the bank and at a depth of 1-2 ft. The water samples were characterized in terms of parameters like calcium, magnesium, sodium, and potassium. The samples were collected by dipping 20 lt. polyethylene vessel such that a steady and true representative of water sample is being trapped, out of which a two litre sample is made out and was brought to the laboratories for further course of analysis.

Eltop (3020) digital pH meter is used for the pH determinations, A Spekol spectrophotometer (CARL, ZEISS, DDR) with 0.995 cm corex cells is used for the absorbance measurements. Elico digital flame photometer is used for the determinations of sodium and potassium.

All the reagents used in these investigations were of analytical reagent grade.

RESULTS AND DISCUSSION

The variation of level of occurrence of trace metals in water was found different from each other due to the variation of solubility of the existing forms of metals in water as well as their availability in the immediate environment. Among the metals, the level of zinc was found higher and mercury level was always less than 0.1 ppb (Table 2). The average levels of metals (in ppm) followed the order $\text{Zn} > \text{Pb} > \text{Cd} > \text{Ni} > \text{Co} > \text{As} > \text{Hg}$. The ranges of variation in the present study revealed that the dissolved constituents of Pb, Cd, Zn and As were above the ranges of unpolluted water indicating their contamination in water (Table I and II). Contamination of metals in water body is normally encountered during manufacture and leaching of various metals containing materials used in our modern life style processes. In natural water system Zn remains as either hydroxide or carbonate form with having almost same solubility which is higher than the solubility of the existing forms of the other metals. This could be the reason for comparatively higher values of Zinc in water.

However the level of metals in aquatic system in most cases remains below the solubility level of the respective elements and appears to be limited by factors other than solubility relations. One mechanism that probably is involved in controlling observed concentration of metals is adsorption by colloidal particles of oxides and hydroxides of manganese or iron or coprecipitation or combination of both and appeared to be major inorganic factors that can maintain concentration of metals at very low level in water.

The trace metal concentration in water showed distinct temporal and spatial variations. Among the metals the concentration of mercury (Hg) remained always below the detection level through out the study period in the entire stretch. Arsenic was found in water with maximum of 3 ppb in all the samples showing no regional preference of occurrence. Thus it could be presumed that the level of As in water (av. 3.0 ppb) remained almost in natural level and there was probably no anthropogenic inputs in the study area for its enrichment. Similar reason could be ascribed to the dissolved levels of Ni and Co and there was contamination of the metals like Pb and Zn throughout the season while occasional in case of Cd.

From the average distribution of all dissolved metals in various seasons, it was clear that the level of occurrence was found higher within Cuttack and Paradip stretch identifying the probable area of contamination to the level of above the tolerance limit of drinking water [7]. However the average levels of all the elements in the entire study stretch remained below the tolerable limit in drinking water as stipulated by WHO. Since the pH of natural water lies in the range of neutral to alkaline, the levels of the studied metals could not rise so much as there are natural mechanisms to remove these metals from aqueous solution and prevent from enrichment. Thus the composition of the water in the present study in respect to trace metal content along with the degree of occurrence revealed similar to what has been reported in domestic sewage [8] of Kolkata Metropolitan Area. Consequently this implied that the higher levels of Pb, Cd and Cr in the specified area could not be due to introduction of domestic sewage alone. Instead, there might have been some industrial influences on the waste water released into the river. Nevertheless, their presence and mode of variations in the present study do indicate that the river water is not at all free from toxic metal contamination instead of great deal of progress during the tenure of the Ganga Action Plan (GAP). This may pose significant impact on the health of this ecosystem because the hydrological mechanism of the Mahanadi river is such that the tidal influx extends upto a distance of about 200 kilometer upstream and accordingly, the contaminants in the river are not instantly diluted but undergo oscillation spending considerable periods within this stretch and provide ample opportunity to interact with every component of this ecosystem. This also enhances the possibility of removal of some fraction of the dissolved metals to the underlying sediments by way of adsorption, flocculation and bio-geo-chemical processes. Thus the sediments with enriched toxic metals can serve as reservoir and may become a potential source to supply the toxic metals in the environment.

Table I

| Location | % Sodium | % Potassium | & Calcium | % Magnesium | % Iron | SAR |
|-----------------|-----------------|--------------------|----------------------|--------------------|---------------|------------|
| Sambalpur | 6.67 | 2.0 | 6.2 | 4.15 | 3.8 | 6.3 |
| Narsinghpur | 7.1 | 1.98 | 5.90 | 3.9 | 4.0 | 6.7 |
| Athgarh | 7.78 | 1.70 | 5.85 | 3.87 | 3.8 | 7.65 |
| Banki | 8.25 | 1.74 | 5.63 | 3.58 | 3.8 | 7.75 |
| Cuttack | 8.44 | 1.65 | 5.4 | 3.45 | 3.65 | 8.2 |
| Paradeep | 8.65 | 1.47 | 5.2 | 3.4 | 3.5 | 8.3 |

Estimation of Calcium is carried out by DTA in presence of Patton and Reader's indicator. The amounts of calcium are in between 5.4 to 6.2% (Table-1). The total hardness of the sample is determined using Erichrome black T against EDTA. The values are expressed in equivalent of calcium carbonate mg./l. The differences between total hardness and calcium

given the amount of magnesium. There is an increasing tendency the values of Magnesium and Calcium as we move from sea-coast.

Table II

| Location | pH | Total soluble salts in P.Pb | Sulphate in P.Pb | Chloride in P.Pb | Cd in P.Pb | Hg in P.Pb | As in P.Pb | Co in P.Pb | Ni in P.Pb | Pb in P.Pb | Zn in P.Pb |
|-------------|------|-----------------------------|------------------|------------------|------------|------------|------------|------------|------------|------------|------------|
| Sambalpur | 7.3 | 0.35 | 85 | 22.0 | BOD | <0.001 | <3 | <4 | <6 | 4.1 | 15 |
| Narsinghpur | 7.33 | 0.35 | 9.4 | 23.5 | -do- | -do- | -do- | -do- | -do- | 4.6 | 13 |
| Athgarh | 7.5 | 0.39 | 120 | 34.0 | -do- | -do- | Hg in P.Pb | -do- | -do- | 5.2 | 14 |
| Banki | 7.8 | 0.323 | 137 | 23.6 | -do- | -do- | <0.001 | -do- | -do- | 11.0 | 15 |
| Cuttack | 7.9 | 0.40 | 160 | 51 | -do- | -do- | -do- | -do- | -do- | 16.0 | 21 |
| Paradeep | 8.0 | 0.38 | 171 | 44 | -do- | -do- | -do- | -do- | -do- | 10.8 | 20 |
| | | | | | | | -do- | | | | |
| | | | | | | | -do- | | | | |
| | | | | | | | -do- | | | | |

Table III. Comparison of the levels of trace metals (ppb) in unpolluted water, drinking water standard to the present study and some common uses of these metals.

| Components | Unpolluted Water Ranges | Drinking Water Std. (WHO 1996) | Present Study Range | Common Uses |
|------------|-------------------------|--------------------------------|---------------------|--|
| Pb | 0.001-0.050 | 0.010 | 4.1-10.8 | Batteries, solder, alloys, pigments, glazes and stabilizes |
| Cd | <0.001 | 0.010 | BDL | Anticorrosive, pigments in plastics, batteries, electronic components |
| Cr | 0.0005-0.002 | 0.050 | Not detected | Tanning, pigments, paints, ceramics and glass |
| Zn | 0.001-0.010 | <3 | 15 - 21 | Pigments, pesticides, galvanization and corrosion resistant alloys |
| Ni | 0.001-0.020 | 0.020 | L6 | Alloys, batteries, stainless steel, tap fittings. |
| As | <0.002 | 0.010 | L4 | Pigments, glass industries, textiles, paper, wood preservation, ammunition, metal adhesive, semiconductors |

B.D.L – Below detection limit.

It is frequently necessary to ascertain the quality of irrigation water so as to gauge the possible effects of this water on the soil. The irrigation water often results in water logging, salinity and alkalinity problems. It is very important to know its quality.

Cuttack and Narasinghpur are both industrial areas. Athgarh boast it self with a lot of cotton industries which usually use Mahanadi river water for bleaching its finished products. After that these waters are fed to Mahanadi again Paper, Soap, Biscuits, mini cement plants in and around Cuttack town also discharge their effluent water into Mahanadi river as a result it becomes polluted. Most of our cultivation depends upon this polluted water.

Amounts of sodium and potassium using flame photomatic technique [3]. It has been observed that sodium values increases as the distance from sea deceases. Potassium value increases as we move from Cuttack to sambalpur. (Table-1)

Sodium Absorption Ratio (SAR) values are found to be between 6.3 to 8.3%. The values of SAR indicated that the water are quite suitable for the application to all sorts of crops in the region for irrigation without any danger of accumulation of sodium at harmful levels.

As regards pH the water is more alkaline at Cuttack and Paradeep (7.9 and 8 respectively). The values show that due to let in of discharges of factories the pH becomes higher. At the same time total soluble salts of these two places are higher (0.40 and 0.38 respectively).

Chloride value at Cuttack and Paradeep are 51 and 44.0 as against 22.0 at Sambalpur. This higher value of chlorine is due to sewage waters coming from different factories located nearby. This high Chlorine content will damage the crops.

So, it was observed that water quality of Mahanadi river is worst at Paradeep and Cuttack region.

REFERENCES

1. Chopra, S.L. and Kanwar, J.S., "Analytical Agricultural Chemistry", Kalyani Publishers, Ludhiana, India (1986).
2. Sankaram, S.A., "Soil Chemical Properties". *Series in Agricultural Chemistry*, Vol. 5, The Bangalore and Publishing Co., Bangalore, India (1977).
3. Vogel, A.I., "Text Book of Quantitative Inorganic Analysis", Longmann Group, London (ELBS Edition), (1975).
4. Methods for physical and chemical analysis of fresh waters by H.L. Golterman, R.S. Clymo and M.A.M. Ohnstad, Blackwell Scientific Publications, London. P.76-91.
5. Hem, J.D., Study and interpretation of the chemical characteristic of natural water, USGS Water Supply Paper, 3rd edition (1989).
6. Hem, J.D., Reactions of metal ions at surfaces of hydrous iron oxide, *Geo. Chim. Cosmo. Citrim. Acta*, **41**, 527 (1977).
7. WHO. Guidelines for drinking water quality. 2nd edition (1996).
8. Ghosh, P.B., *et al.*, Distribution of Lead, Cadmium and Chromium in the waste water of Calcutta Canals, *Res. J. Chem and Environment*, **4(3)**, 33 (2000).

