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# Physico-chemical Properties of Water Samples from Manipur River System, India

**[1]SINGH M. R; [2]*GUPTA, ASHA; [3]BEETESWARI, KH.**

*[1]Research Scholar,Ecology Research Laboratory,Department of Life sciences, Manipur University, Canchipur,Imphal (Manipur) India PIN 795003, e-mail millow_singh@yahoo.com*

*[2*]AssociateProfessor,Department of Life sciences, Manipur University, Canchipur,Imphal (Manipur) India PIN 795003, phone 91-0385-2444319, e-mail anjalika_22000@yahoo.co.in*

*[3]Reasearch Associate, Ecology Research Laboratory,Department of Life sciences, Manipur University, Canchipur,Imphal (Manipur) India PIN 795003, e-mail muskundo@rediffmail.com*

**ABSTRACT:** Assessment of physico-chemical parameters were carried out during April 2008 to March 2009 from four rivers namely the Imphal, Iril, Thoubal and Manipur located in Manipur, a north-eastern State of India bordering Myanmar. Sites I, IV, V and VI were subjected to various anthropogenic activities of man, passing through the urban residential areas while sites II and III from Manipur river were located in a forested watershed and free from human disturbances. Maxima of TDS 870 mg/l, conductivity 467µS/cm, $NO_3$-N 0.550 mg/l, $PO_4$-P 0.068 mg/l and K 9.00 mg/l were recorded during rainy season while maxima of free $CO_2$ 22.3 mg/l, total alkalinity 168.0 mg/l, Chloride 42.63 mg/l and total hardness 136.0 mg/l were observed during summer from the rivers indicating degradation of water quality during rainy season than summer. Values of DO was below the minimum permissible limit (4.43 mg/l) and free $CO_2$ beyond the maximum limit (22.30 mg/l) during summer season at site V .The values of the studied parameters were more during rainy season in Thoubal river followed by Imphal, Iril and Manipur rivers. The results indicated that most of the physico-chemical parameters from Manipur river system were within the WHO limits for drinking water and, therefore, may be suitable for domestic purposes. @ JASEM.

Rivers and streams are highly heterogeneous at spatial as well as temporal scales, and several investigators have documented this heterogeneity focusing on the physico-chemical dynamics of rivers. Variation in the quality and quantity of river water is widely studied in the case of several world rivers. Riedel *et al.*2000 examined the spatio-temporal variation in trace elements in Patuxent river, Maryland, while Sileika *et al.*2006 reported the variations in nutrient level in the Nemunas river of Russia. Schaefer and Alber ,2007 studied nitrogen and phosphorus in Altamaha river, Georgia.

Manipur (Latitude 23.80° N to 25.68°N and Longitude 93.03°E to 94.78°E) a state in the north-east corner of India has a subtropical climate with average temperature ranging from $0^oC$-$32^oC$ and an annual rainfall as 1657.6 mm. The state has a total geographical area of 22,356 sq.km and is characterized by three river systems namely-Manipur, Chindwin river Barak. The state is drained by various streams which belong to the Manipur river and its tributaries along with other smaller streams and associated lakes forming the water resources of the valley. A catchment of 6,332sq.km constituting about 28.4% area of the state discharge maximum quantity of water through Manipur river system during monsoon months (May-September)and frequently inundate the land along their bank.

The present study is an attempt to characterize the trends in physico-chemical properties of water quality from the four rivers of Manipur river system viz; the Imphal, Iril, Thoubal and Manipur rivers with a view to find out some clues for river water management.

## MATERIALS AND METHODS

Six sites were selected viz; site I (Sanjenthong) from Imphal river ; site II (Serou Laimaning); site III (Ningthem Hidane) from Manipur River; Site IV (Thoubal Bridge) from Thoubal River; site V (Sawombung bridge) and Site VI (Nungpokpi) from Iril River. At each sampling location, composite surface water was collected at the middle of the river and stored in clean polyethylene bottles that have been pre-washed with $HNO_3$ and thoroughly rinsed with deionised water. Water temperature, pH, depth, transparency, water current were determined in the field because of their unstable nature. Water temperature was measured with the help of a mercury thermometer, transparency with secchi disc, conductivity with pen type DIST 3 model and pH with pen type pH meter model 600, depth using meter scale and water current by flow mate Model 2000 Marsch-McBirney, INC. Alkalinity was determined by titrating a known volume of water sample with 0.02MHCl. Dissolved oxygen (DO) was determined by Winkler's titration. Total dissolved solid (TDS) was determined gravimetrically by evaporating a known volume of water to dryness in a pre-weighed crucible on a steam bath. Total hardness was determined by titrating with EDTA using Eriochrome black T as indicator while the rest were analysed in the laboratory using standard APHA, 2005. Each sample was analysed in duplicate and the mean result reported.

*e-mail millow_singh@yahoo.com; anjalika_22000@yahoo.co.in; muskundo@rediffmail.com*

**RESULTS AND DISCUSSION**

The results of physico-chemical characteristics of 4 rivers from each site are reflected in **Table 1**. Surface water temperature ranged from 16°C-28°C showing minimum and maximum values during winter and summer seasons respectively in all the sites. According to Fakayode, (2005), the pH of a water body is very important in determination of water quality since it affects other chemical reactions such as solubility and metal toxicity. pH value ranged from 6.5 to 7.9. It was found to be alkaline in nature during winter in all the four rivers. No significant difference in pH was observed during the study period except during summer when the pH dropped to an acidic range 6.5-6.9. The pH of the water under study in both seasons is within the WHO standard of 6.50-8.50. This water could therefore be regarded as neutral and unpolluted (Fakayode 2005). The transparency of the river was found to be lowest (8.0 cm) during rainy season at site V in Iril River and highest (48.5 cm) during winter (site II) in Manipur river. Reduced transparency during rainy season may be due to erosion of soil carried by run off from the catchment areas. Water current in the 4 rivers lies within the ranges of 0.20 m/sec at site III to 1.104 m/sec at site II in Manipur river with a minimum and maximum values recorded during summer and winter respectively. Seasonal variation in water current has been reported in streams of Palani hills (Sivaramakhrishhnan and Venkataraman (1990) and in Kurangani stream (Balasubramanian *et al*., 1992). Depth of the rivers varied from 18.5 cm-165cm. It was low during summer at site III in Manipur river and deepest during rainy at site VI in Iril river. Conductivity is a good and rapid method to measure the total dissolved ions and is directly related to total solids. Higher the value of dissolved solids, greater the amount of ions in water (Bhatt *et al*., 1999). Conductivity values were minimum at site I in Imphal river (65 µS/cm) and maximum at site VI (467 µS/cm) in Iril river during rainy season. In the present study, the conductivity values were far less than the recommended values and hence the water can safely be used for domestic and agricultural purposes. A few studies in the river Halda were reported by Patra and Azadi, 1987 (94.18 µS/cm) and by Marshall and Winterbourn, 1979 in African river Nourouri and a stream in New Zealand (278 and 234 µS/cm respectively). Total Dissolved Solid (TDS) depend on various factors such as geological character of watershed, rainfall and amount of surface runoffs and gives an indication of the degree of dissolved substances. The observed TDS values were comparatively lower at site V (280 mg/l) in Iril river during winter season and higher at site III (870mg/l) during rainy season in Manipur river. Its lowest values were recorded during winter season which gradually increased with the onset of rainy season due to washed in materials from the catchment areas and erosion of the river bank. This result was supported by the finding of Payne, 1986. Dissolved Oxygen (DO) content, plays a vital role in supporting aquatic life and is susceptible to slight environment changes. Oxygen depletion often results during times of high community respiration. And hence DO has been extensively used as a parameter delineating water quality and to evaluate the degree of freshness of a river (Fakayode, 2005). It is also an important limnological parameter indicating level of water quality and organic pollution in the water body (Wetzel and Likens, 2006). DO content varied from 4.43 mg/l - 13.09 mg/l in the 4 rivers. It was found below the WHO permissible limit in Thoubal and Iril rivers sites during summer and hence not recommended for drinking purposes during these periods. Seasonal variation in DO content is related to temperature and biological activities (Chapman and Kimstach, 1992). The values are also within the WHO permissible limits. Free $CO_2$ values were found to be maximum during summer in almost all studied sites. Its maximum value (22.3 mg/l) lies in site V (Iril River). The higher values of Carbondioxide recorded in summer might have been due to deoxygenation , a feature observed also by Talling (1957) while investigating the White Nile. The rise in temperature in the river water could be correlated with increase in carbondioxide levels (Talling, 1957) when the water level decreased sharply during summer. Alkalinity of water is a measure of weak acid present in it and of the cations balanced against them (Sverdrap *et al*., 1942). Total alkalinity of water is due to presence of mineral salt present in it. It is primarily caused by the carbonate and bicarbonate ions. Total alkalinity of the four rivers water fluctuated from 54 mg/l -168 mg/l and found to be within permissible limit. It was minimum during winter at site I in Imphal River and maximum during summer at site IV in Thoubal river. It is apparent that chloride can be taken as one of the indices of water pollution from sewage and drains in the vicinity of the towns within the drainage basin. Chloride content of the rivers varied from 20.66mg/l-42.63mg/l. The chloride reached their maximum value during summer at site III when the water level was considerably low and reached minimum during the rainy season at site I (Imphal river) with comparatively high water levels. Our observation tally with those of Ahmed, 2004. The chloride in Potamac waters appear to be mainly due to sewage contamination (Klaein, 1957). Total hardness is the parameter of water quality used to describe the effect of dissolved minerals (mostly Ca and Mg), determining suitability of water for domestic, industrial and drinking purposes and attributed to presence of bicarbonates, sulphates, chloride and nitrates of calcium and magnesium( Taylor, 1949). Its values

in the 4 rivers varied from 38 mg/l – 136 mg/l. Minimum value in site I from Imphal river during rainy and maximum value in Thoubal River from site IV during summer season were recorded.

**Table 1**. Physico-chemical characteristics of water from 6 studied areas.

| Sl. No | Physico-chemical parameters | STUDY AREAS | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | Imphal River | Manipur River | | Thoubal River | Iril River | | WHO limits |
| | | I | II | III | IV | V | VI | |
| 1 | pH | 6.8 - 7.9 (S) (W) | 6.5-7.9 (W) (R) | 6.8-7.9 (S) (R) | 6.9-7.9 (S) (W) | 7.0-7.9 (S) (W) | 6.9 - 7.8 (S) (W) | 6.5 – 8.5 |
| 2 | Temperature($^{o}$C) | 17.5 – 28.0 (W) (S) | 16 .0– 25.0 (W) (S) | 16 .0– 26.0 (W) (S) | 18 .0– 26.0 (W) (S) | 16.0 – 26.0 (W) (S) | 16.0 – 28.0 (W) (S) | 30 - 35 |
| 3 | Secchi Transparency(cm) | 16.5-38 (R) (S) | 15.5-48.5 (S) (W) | 14.0 -43.0 (S) (W) | 10.3 – 45.0 (S) (W) | 8.0- 40.0 (R) (W) | 7.5-35.0 (R) (W) | N/A |
| 4 | Water current (m/sec) | 0.33-0.902 (S) (R) | 0.29-1.104 (S) (R) | 0.20-1.00 (S) (W) | 0.308- 0.812 (S) (R) | 0.29-0.755 (S) (W) | 0.27-0.970 (S) (W) | N/A |
| 5 | Depth (cm) | 27.0-160.0 (S) (R) | 19.0-125.0 (S) (R) | 18.5-120.0 (S) (R) | 39.1-170.0 (S) (R) | 23.0-136.0 (S) (R) | 30.0-165.0 (S) (R) | N/A |
| 6 | Total Dissolved Solids (TDS) (mg/l) | 308.0-648.0 (W) (R) | 402.0-863.0 (W) (R) | 418.0-870.0 (W) (R) | 398.0-686.0 (W) (R) | 280.0-680.0 (W) (R) | 300.0-688.0 (W) (R) | 500 |
| 7 | Conductivity (µS/cm) | 65.0-285.0 (W) (R) | 124.0-365.0 (W) (R) | 125.0-460.0 (W) (R) | 133.0-464.0 (W) (R) | 117.0-452.0 (W) (R) | 120.0-467.0 (W) (R) | 750 |
| 8 | Dissolved Oxygen (DO) (mg/l) | 5.02-9.29 (S) (R) | 6.05-10.07 (R) (W) | 6.81-11.49 (R) (R) | 4.48-11.89 (S) (R) | 4.43-13.09 (S) (R) | 4.83-11.49 (S) (W) | 5.0-7.00 |
| 9 | Free $CO_2$ (mg/l) | 8.8-20.4 (R) (S) | 7.5-19.8 (R) (S) | 7.00-19.5 (S) (W) | 8.6-21.1 (S) (S) | 8.8-22.3 (S) (S) | 8.8-19.8 (R) (S) | 22 |
| 10 | Total alkalinity (mg/l) | 54.0 - 112.0 (W) (R) | 68.0-136.0 (R) (S) | 54.0-140.0 (W) (S) | 70.0-168.0 (R) (S) | 64.0-148.0 (W) (S) | 70.0-145.0 (W) (S) | 120 |
| 11 | Chloride (mg/l) | 20.66-38.40 (R) (S) | 22.20-38.92 (R) (S) | 23.53-40.95 (R) (S) | 26.98-42.63 (R) (S) | 24.14-32.66 (R) (S) | 26.98-32.34 (R) (S) | 250 |
| 12 | Total hardness (mg/l) | 38.0-102.0 (R) (S) | 40.0-110.0 (R) (W) | 44.0 – 115.0 (R) (W) | 52.0 – 136.0 (S) (S) | 50.0 – 120.0 (R) (S) | 46.0 – 116.0 (R) (S) | 300 |
| 13 | Ca hardness (mg/l) | 7.21-10.81 (R) (W) | 6.01-7.82 (R) (S) | 6.64-8.52 (W) (R) | 12.02-17.63 (R) (W) | 9.02-12.92 (R) (W) | 10.05-13.86 (R) (S) | 100 |
| 14 | Mg hardness (mg/l) | 4.38-17.49 (R) (W) | 3.44-16.28 (R) (W) | 3.46-16.05 (R) (W) | 2.46-21.44 (R) (W) | 4.84-18.63 (R) (W) | 6.41-21.42 (R) (W) | 150 |
| 15 | $NO_3$-N (mg/l) | 0.203 - 0.421 (W) (R) | 0.160-0.424 (W) (R) | 0.168-0.426 (W) (R) | 0.210-0.451 (W) (R) | 0.223-0.390 (W) (R) | 0.216-0.550 (W) (R) | 45 |
| 16 | $PO_4$-P (mg/l) | 0.021-0.061 (W) ( R ) | 0.010-0.054 (S) ( R ) | 0.018-0.056 (W) (R ) | 0.018-0.068 (W) (R ) | 0.012-0.056 ( S ) ( R ) | 0.018 - 0.06 ( S ) ( R ) | 0.1 |
| 17 | K (mg/l) | 3.00 - 6.00 ( S ) ( R ) | 4.00 - 7.00 (W) ( R ) | 3.00 - 8.00 (W) ( R ) | 3.00 - 9.00 (W) (R ) | 2.00 - 8.00 ( W ) ( R ) | 2.00 - 8.00 ( W ) (R ) | 50 |

The values are ranges for a particular parameter; N/A not available; R, W and S in parentheses denote the value obtained during rainy, winter and summer months.

The high value of total hardness at site IV may be due to discharge of sewage from nearby market places, use of soaps and detergents by laundries, washing, bathing by people and cremation ghat installed near the river bank. Ca hardness values varied from a minimum of 6.01 mg/l at site II during rainy to a maximum of 17.63mg/l at site IV during winter. Mg hardness were minimum (2.46 mg/l) during rainy and maximum (21.44 mg/l) during winter at site IV in Thoubal river. Both Ca and Mg hardness values were found to be minimum during rainy and maximum during winter seasons. Similar trends were also reported by Sah *et al.,* 2000; Singh *et al.,* 2009. Nitrate in surface water is an important factor for water quality assessment (Johnes and Burt, 1993). The presence of nitrates in a lotic system depends mostly upon the activity of nitrifying bacteria, stream currents and catchment characteristics. Nitrate concentration ranged from 0.160 mg/l- 0.451 mg/l minimum being during winter at site II in Manipur river and maximum being during rainy season at site IV in Thoubal river. Nitrate is attributed mainly to anthropogenic activities such as run off water from agricultural lands, discharge of household and municipal sewage from the market place and other effluents containing nitrogen species. Similar observations were also reported by Royer *et al.,* 2004. Phosphorus is the first limiting nutrient for plants in freshwater (Stickney, 2005) which regulates the phytoplankton production in presence of nitrogen. It is available in the form of phosphate ($PO_4$-P) in natural waters and generally occurs in low to moderate concentration. Agriculture runoff containing phosphate fertilizers as well as the waste water containing the detergents etc. tend to increase $PO_4^{3-}$ pollution in water. High phosphates values were observed during rainy season in all the 4 rivers while low values were observed during summer season. Phosphate content of the river water varied from a minimum of 0.010mg/l at site II in Manipur River to a maximum of 0.058 mg/l at site IV in Thoubal river. Our observation is in conformity with the work of Sah *et al.,* 2000. Potassium is required for all cells principally as an enzyme activator and stored in the plant tissues than in surrounding medium (Hornes and Goldman, 1983). Values of Potassium was maximum (9.00mg/l) during rainy season at site IV and minimum (2.00mg/l) during winter season at site VI. Similar observations were also reported by Zafar and Sultana (2008).

The physico-chemical characteristics of water quality analysed during the study period from the 4 rivers of Manipur river system namely the Imphal, Iril, Thoubal and Manipur rivers revealed that due to anthropogenic activities like dumping and throwing of garbages, municipal waste alongside

the river bank, washing clothes mostly by laundries, bathing, cleaning utensils, mining of sand from the river bed, the water quality is becoming deteriorated. Although the lowest amount of DO in site V was below the permissible limit as indicated by WHO standard, it may be considered a temporary phase. The values of the studied parameters were more during rainy season in Thoubal river followed by Imphal, Iril and Manipur rivers. The results indicated that most of the physico-chemical parameters from Manipur river system were within the WHO limits for drinking water and, therefore, may be suitable for domestic purposes. The striking characteristics of the rivers are their high ionic content reflected in high conductivity and total dissolved solids during rainy season. Though nutrients levels were low during the study period, however they reflected an increased trend during rainy season. Therefore there is a need to properly manage wastes in the city and control and monitor human activities in order to ensure that such activities have minimal negative effects on the city stream; even though the nutrient concentrations were low, care must be taken by inhabitants to avoid eutrophication in the rivers.

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