**Poll Res. 41 (4) : 1261-1267 (2022)**

ISSN 0257–8050

**DOI No.: http://doi.org/10.53550/PR.2022.v41i04.019**

# WATER QUALITY ASSESSMENT OF KONGBA RIVER, MANIPUR, INDIA

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(Received 16 June, 2022; Accepted 18 August, 2022)

## ABSTRACT

**A preliminary study on the physico-chemical parameters of Kongba River was carried out on the parameters like water temperature, total solids, total suspended solids, total dissolved solids, turbidity, conductivity, pH, free carbon dioxide, dissolved oxygen, biochemical oxygen demand, chemical oxygen demand, chloride, total hardness, calcium, magnesium, total alkalinity, sodium, potassium, sulphate and inorganic phosphate at seven selected sites. Site I,II,III and IV are river water, while site V, VI and VII are major drain water which joins and pollute the river system. Water Quality Index value of Kongba river ranges from 159.16 to 272.36. Site III has the highest WQI value of 272.36, while site II has the lowest value of 159.16. Major drains and various anthropogenic activities played an important role in deteriorating the water quality of Kongba river.**

**KEY WORDS :** Kongba river, Physico-chemical parameters, Water quality index, Pollution.

## INTRODUCTION

Rivers are critical for human and environmental existence and health by supplying freshwater resources. Furthermore, rivers are the most significant water resources in a watershed for agriculture, home water supply, industrial usage, and other purposes, therefore pollution causes serious hygienic and ecological difficulties. Due to increased anthropogenic activities, urbanisation practices, and irrigational and livestock activities along the river banks, the majority of urban rivers have deteriorated. A healthy river and environment necessitate good water quality. Various water quality criteria are measured to determine the status of river water and if it is suitable for any use.

Kongba River of Manipur is a freshwater river of Manipur which lies between Latitude 24°43'47.35"N to 24°59'13.924"N and Longitude 93°56'9.305"E to 94°1'56.25"E (Fig.1). Having a catchment/watershed area of 144.2 square kilometres, Kongba River originates from the hill ranges of Sinam Komand Ishing The Bimani village at a highest elevation of 1600 MSL (DOE & CC). It has been neglected for many years and is at the brink of extinction. Various anthropogenic activities, uncontrolled discharge of untreated domestic sewage, dumping of household waste, washing of clothes, utensils and kitchen gardening at river banks are the major factors for deteriorating of river water quality. Although the river is small and short in its length, the river plays an important role in socio-economic status of the nearby villages. In the earlier days, the river served as a water source for irrigation and domestic water supply. However as of present, the river is subjected to various anthropogenic activities from domestic purposes such as bathing including animals, washing clothes and utensils, dumping of household garbage, fishing etc. that may deteriorate water quality. Presently the quality of the river is too bad that it is more or less the same quality as a sewage system. The main objective of the study is to analyse the water quality of the Kongba river based on the various water quality parameters determine the status of the river water and whether it is safe for any purpose

## MATERIALS AND METHODS

After a field trip along the Kongba river covering a distance of about 14 km, seven sampling sites which were highly polluted were identified for the study. The seven sites (Table 1) selected for the study are as follows of which four sites viz; Site I (Khurai Heinoumakhong); Site II (Kongpal Kshetri Leikai); Site III (Kongba Nandeibam Leikai); Site IV (Kyamgei) are from Kongba river; Site V(JNIMS drain); Site VI (Kongpal Kshetri Leikai drain) and Site VII (Wangkhei Drain) are from major drains falling into the Kongba river. At each sampling location, composite surface water was collected and

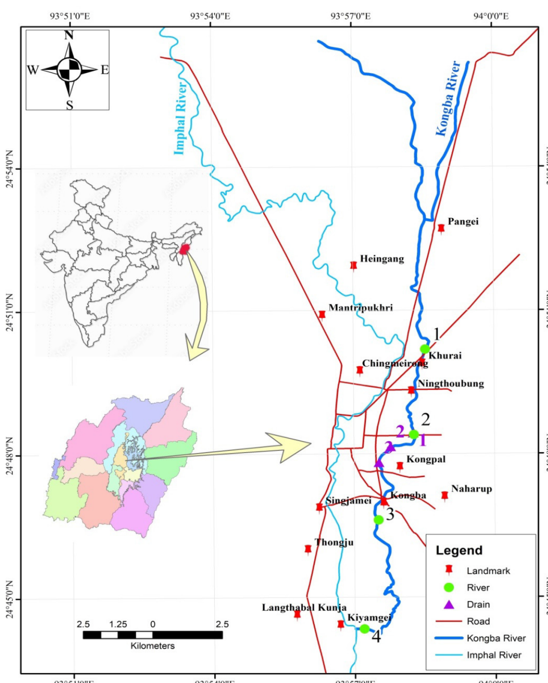


**Fig. 1.** Map showing study location and sampling sites.

stored in clean polyethylene bottles that have been pre-washed and thoroughly rinsed with deionised water.

**Selection of the sampling spots**: Sampling spots for analysis mentioned in the location map. The seven sites selected for the study are as follows of which four sites viz; Site I (Khurai Heinoumakhong); Site II (Kongpal Kshetri Leikai); Site III (Kongba Nandeibam Leikai); Site IV (Kyamgei) are from Kongba river; Site V (JNIMS drain); Site VI (Kongpal Kshetri Leikai drain) and Site VII (Wangkhei Drain) are from major drains (Figure 2) falling into the Kongba river.

**Sample Collection**: Water samples were collected in one litre polyethylene bottle previously soaked with nitric acid and then rinsing with distilled water. The collected water samples were analysed by the standard protocol method mention below:

**Sample Preservation**: Collected water sample, was brought in laboratory and were stored at 4 degree Celsius.

## PHYSICO-CHEMICAL PARAMETER ANALYSIS

All the parameters were analysed (Table 2) using APHA (2017) and Trivedy and Goel (1986) Laboratory manual.

### Calculation of Water Quality Index (WQI)

In this study, the calculation of Water Quality Index (WQI) used was developed by Brown in 1972 and adopted by various other researchers (Cude, 2001; Khwakaram, 2012) which was made using the Weighted Arithmetic water quality index method and took the form:

$$WQI = \sum_{i=1}^{n} QiWi / \sum_{i=1}^{n} Wi$$

Where,

n = number of variables or parameters

Qi = Water Quality rating of the $i^{th}$ parameter

Wi = Unit Weight of water quality parameter

**Table 1.** Water sampling sites of Kongba River

| Sampling sites | Latitude | Longitude |
|---|---|---|
| Site I (Khurai Heinoumakhong) | 24°50'11"N | 93°58'32"E |
| Site II (Kongpal Kshetri Leikai) | 24°48'24"N | 93°58'17"E |
| Site III (Kongba NandeibamLeikai) | 24°46'37"N | 93°57'31"E |
| Site IV (Kyamgei) | 24°44'20"N | 93°57'11"E |
| Site V (JNIMS drain) | 24°48'26"N | 93°58'16"E |
| Site VI (Kongpal Kshetri Leikai drain) | 24°48'9"N | 93°57'47"E |
| SiteVII (Wangkhei Drain) | 24°47'49"N | 93°57'32"E |

*The location details is based on Solocatormobile app


**Fig. 2.** Kongba River and its major drains

**Table 2.** Parameters and the detection method

| Sl. No. | Parameter | Detection Method |
|---|---|---|
| 1. | Temperature | Calibrated mercury thermometer |
| 2. | Total Solids (TS) | Laboratory method |
| 3. | Total dissolved Solid | Digital TDS meter |
| 4. | Total suspended Solids (TSS) | Difference between Total Solid and Total dissolved solids |
| 5. | Turbidity | Digital nephelo-turbidity meter |
| 6. | Electrical conductivity | Digital electrical conductivity meter |
| 7. | pH | Eco pH meter |
| 8. | Free carbon dioxide | Titrimetric method at the sampling spot |
| 9. | Dissolved Oxygen (DO) | Winkler's titrimetric method |
| 10. | Biochemical Oxygen Demand (BOD) | Titrimetric method |
| 11. | Chemical Oxygen Demand (COD) | Acid digestion at digester for two hours followed by analysis using Digital COD Analyser of Spectra lab |
| 12. | Total Hardness | Titrimetric method |
| 13. | Calcium | |
| 14. | Magnesium | |
| 15. | Total Alkalinity | |
| 16. | Chloride | |
| 17. | Sodium | Microprocessor flame photometer |
| 18. | Potassium | |
| 19. | Sulphate | Turbidimetric method using doubled beam UV spectrophotometer. |
| 20. | Inorganic Phosphate | |

For assessing water quality, first, the quality rating scale (Qi) for each water parameter was calculated by using the following equation:

$Qi = [(Va – Vi) / Vs – Vi)] x 100$

Where, Qi = Quality rating of $i^{th}$ parameter for total on $n^{th}$ water quality parameters,

Va = Average value of the water quality parameter obtained from the study,

Vi = Ideal value of that water quality parameter can be obtained from standard tables.

(Ideal value for pH =7, dissolved oxygen = 14.6 mg/l, and for other parameters it is equal to zero.)

Vs = Recommended standard value of water quality parameter.

The Relative (Unit) Weight (Wi) was calculated by a value inversely proportional to the recommended standard (Si) for the corresponding parameter using the following expressions: Wi = K / Si,

Where,

Wi = Relative (Unit) Weight for $n^{th}$ parameter,

Si = Standard permissible value for $n^{th}$ parameter,

K = Proportionality constant.

The overall water quality rating (Table 3) is categorised according to Tyagi *et al.* (2013).

## RESULTS AND DISCUSSION

The results of the water quality parameters of Kongba River from each site are reflected in Table 4.

For the present study, the sampling was carried out in the month of April, 2022 (pre-monsoon). During the sampling period, the water temperature ranged from 22 °C to 25 °C. Water temperature is one of the important parameter that influences the physical, chemical and biological properties of a water system. Higher the temperature lower is the dissolved oxygen. So, water temperature plays an important role in the quality of water and aquatic life formsof the river. The water temperature of site I, II, III and IV which are of river water ranges between 22 °C -23 °C while that of site V,VI and VII which are drain water is comparatively recorded a higher temperature (25 °C).

Total solids are the combination of total dissolved solids and total suspended solids (Trivedy and Goel, 1986). Total solids of the river water from site I to site IV was found in the range of 257.4 to 486.8 mg/l and major drain water of site V to VII ranges from 200 to 1068 mg/l. Site VI records the highest total solid of 1068 mg/l. It is one of the major drain of Kongpal Kshetri Leikai which has high sewage discharge rate that directly join to Kongba river. Total solids also affect water clarity. Higher solids decrease the passage of light through water, thereby slowing photosynthesis by aquatic plants. Water will heat up more rapidly and hold more heat; this in

**Table 3.** Water quality rating

| Water Quality Index Value | Rating of Water quality | Grading |
|---|---|---|
| 0 - 25 | Excellent | A |
| 26 - 50 | Good | B |
| 51 - 70 | Poor | C |
| 71 - 100 | Very poor | D |
| Above 100 | Unsuitable for drinking purposes | E |

**Table 4.** Water quality parameters from the seven sites.

| Sl. No. | Parameters | Site I | Site II | Site III | Site IV | Site V | Site VI | Site VII |
|---|---|---|---|---|---|---|---|---|
| 1. | Water Temperature (°C) | 22 | 22 | 23 | 23 | 25 | 25 | 25 |
| 2. | Total Solid (mg/l) | 257.4 | 332.6 | 455.6 | 486.8 | 200 | 1068 | 402 |
| 3. | Total Dissolved Solid (mg/l) | 189 | 232 | 403 | 369 | 164 | 314 | 336 |
| 4. | Total Suspended Solid (mg/l) | 68.4 | 100.6 | 52.6 | 117.8 | 36 | 754 | 66 |
| 5. | Turbidity (NTU) | 24 | 16 | 28 | 42 | 24 | 240 | 30 |
| 6. | Conductivity (μS/cm) | 348 | 424 | 688 | 578 | 304 | 586 | 618 |
| 7. | pH | 7.23 | 7.30 | 7.19 | 7.47 | 7.21 | 7.34 | 7.40 |
| 8. | Free $CO_2$ (mg/l) | 13.2 | 17.6 | 55 | 26.4 | 39.6 | 52.8 | 50.6 |
| 9. | DO (mg/l) | 2.42 | 2.21 | 1.21 | 8.46 | 2.21 | 0 | 2.01 |
| 10. | BOD (mg/l) | 8.46 | 8.46 | 18.15 | 6.0 | 10 | 26.1 | 23.1 |
| 11. | COD (mg/l) | 26.18 | 14.84 | 32.88 | 13.56 | 19.34 | 36.84 | 39.63 |
| 12. | Hardness(mg/l) | 260 | 320 | 340 | 380 | 126 | 150 | 142 |
| 13. | Calcium (mg/l) | 30.46 | 33.67 | 40.88 | 48.10 | 28.06 | 38.48 | 38.48 |
| 14. | Magnesium (mg/l) | 44.82 | 57.49 | 57.98 | 63.34 | 13.64 | 13.15 | 11.21 |
| 15. | Total alkalinity (mg/l) | 220 | 280 | 490 | 390 | 245 | 315 | 325 |
| 16. | Chloride (mg/l) | 68.16 | 71 | 86.62 | 86.62 | 63.9 | 88.04 | 96.56 |
| 17. | Sodium (mg/l) | 36.5 | 38.5 | 53.8 | 52.7 | 23.2 | 37.1 | 40.0 |
| 18. | Potassium (mg/l) | 5.4 | 5.5 | 9.5 | 7.5 | 3.7 | 14.9 | 12.9 |
| 19. | Sulphate (mg/l) | 23.15 | 28.16 | 26.40 | 25.10 | 22.50 | 40.87 | 41.14 |
| 20. | Inorganic Phosphates (mg/l) | 0.385 | 1.689 | 0.765 | 1.515 | 1.027 | 2.347 | 2.600 |

turn, might adversely affect aquatic life that has adapted to a lower temperature regime (EPA). The higher total solid in the river system can be attributed to the discharge of sewage from the major drains, road run-off and soil erosion.

Total dissolved solids consist of calcium, chlorides, nitrate, phosphorus, iron, sulphur, and other ions particles that will pass through a filter with pores of around 2 microns in size (EPA).TDS ranges from 189 to 403 mg/l site I to IV and for site V to VII, the value ranges 164 to 336 mg/l. Site IV has the highest TDS value of 403 mg/l. Dumping of garbage, household organic waste and sewage might be the major factor.

Total suspended solid include silt and clay particles, plankton, algae, fine organic debris, and other particulate matter. These are particles that will not pass through a 2-micron filter (EPA). TSS ranges from 52.6 to 117.8 mg/l for site I to IV, and for site V to VII, the value ranges from 36 to 754 mg/l.

The electrical conductivity (EC) of water is a measure of the ability of a solution to carry or conduct an electrical current (Tchobanoglous *et al*., 2003). Since the electrical current is carried by ions in solution, the conductivity increases as the concentration of ions increases (APHA, 2017). Site III of river water has the highest conductivity of 688 µS/cm. While the site VII of drain water has the highest conductivity of 618 µS/cm which might be due to the highest contents of TDS and chemical ions like sodium, chloride.

The pH of the river from site I to site IV and also that of the major drains from site V to site VII is in the range between 7.19 to 7.47 are under the permissible limit of BIS. pH range from 6-8 is generally found in natural water (Thakre *et al*., 2010). pH is an important factor which determines the water quality since it affects other chemical reactions such as solubility and metal toxicity (Fakayode *et al.,* 2005).

Free carbon dioxide is a present in the form of dissolved gas in water. It is essential for the photosynthetic activities of aquatic submerge plants. Site III of river water and site VI of drain water have the highest free carbon dioxide value of 55 mg/l and 52.6 mg/l respectively. High carbon dioxide in water indicates higher microbial population and pollution rate.

Dissolved oxygen is one of the most important indicators of water quality and the DO level in natural water is determined by the physical, chemical, and biochemical activities in the water bodies. It is introduced into the water as a by-product of aquatic plant photosynthesis and atmospheric wind interaction with the water. The solubility level of oxygen is related to pressure and temperature. In a freshwater system with 1 atm pressure, at, DO reaches approximately 14.6, 9.1, 8.3, and 7.0 mg/l at 0°C, 20°C, 25°C, and 35 °C, respectively (Patel and Vashi, 2015. Low oxygen in water can kill fish and other organisms present in water. DO is essential for the survival of fish and other aquatic life forms and a minimum DO of about 4 mg/l is required for the living organisms. Sites I and II of river had lesser DO value less than 3 mg/l, so it is not safe for drinking, domestic purposes and aquatic life forms. The introduction of organic waste, especially from the domestic sewage of the nearby residents might be one of the major factors for the low level of DO in water. While the site IV had the highest DO value of 8.06 mg/l because it had clear vegetation cover. Site III and VI had no dissolved oxygen content because the site had thick water hyacinth, algal growth and other unwanted plant cover, moreover the BOD level is also high.

Biochemical oxygen demand (BOD) is the amount of oxygen required by aerobic biological organisms to break down organic material present in a given water sample at certain temperature over a specific time period. Organic material that is discharged into natural waters causes a rapid increase in the growth of micro-organisms that deplete the oxygen required for other aquatic life. Site III of river water and site VI of drain water have the highest BOD value of 18.15 mg/l and 26.1 mg/l respectively. It is due to high levels of organic pollution and microbial population, caused usually by poorly treated wastewater. BOD value higher than 3 mg/l is not recommended for outdoor bathing (PIB.2012).

Chemical Oxygen Demand (COD) is defined as the amount of a specified oxidant that reacts with the sample under controlled conditions (APHA, 2017). Site III of river and site VII of drain water have the highest COD value of 32.88 mg/l and 39.63 mg/l respectively. It is due to high levels of organic and inorganic materials content. Higher BOD levels will give higher COD level simultaneously. It can easily indicate the pollution level of a water body.

Total hardness of water is due to the concentration of calcium carbonate and magnesium with other polyvalent ions of some other metals like iron, zinc, aluminium and manganese, etc. (Trivedy and Goel, 1986). Site IV and site VI have the highest hardness value of 380 mg/l and 150 mg/l respectively. Most of the sampling sites has high hardness value because the river is almost stagnant, moreover the organic and inorganic material flows from the sewage is also the key factor.

Calcium is one of the abundant elements which come from the leaching of rocks and soils in river system. It is a major component of hardness of water. Site IV of river water and site VI, VII of drain have the highest calcium content of 48.10 mg/l and 38.48 mg/l respectively.

Magnesium contributes in hardness of water. Site IV of river water has the highest value of 63.34 mg/l. This site is the downstream of the Kongbariver, so various organic, inorganic components and sewage finally aggregate here, so this may be the main reason of high magnesium content.

Total alkalinity of water body is a measure of its capacity to neutralise acid to a designated pH (APHA, 2005). Site III of river water and site VII of drain water have the highest alkalinity value of 490 mg/l and 325 mg/l respectively. Such high in alkalinity may be high concentration of domestic sewage and consumption of fertilizers in agriculture (Waribam *et al.*, 2015).

Chlorideis one of the major inorganic anions, or negative ions, in saltwater and freshwater, sources may be from septic tank effluent, animal waste, water softener regeneration, chlorinated drinking water, and potash fertilizer. Site III and IV of river water and site VII of drain water have the highest chloride content of 86.62 mg/l and 96.56 mg/l respectively. Elevated concentrations of chloride in streams can be toxic to some aquatic life (USGS). The rate of chloride increases the eutrophication which may be due to industrial and domestic disposal (Naz, 2014).

Sodium in river water may be derived from natural salt deposits, sewage and fertilizers.Site III of river water and site VII of drain water have the highest sodium content of 53.8 mg/l and 40.0 mg/l respectively. The value is high due todumping of domestic waste, sewage and high human population at the periphery of site III and IV.

Potassium is positively charged ion when it dissolves in water (APHA, 2017). It is the fourth naturally occurring cation in fresh water ecosystem and is always found lesser value than sodium, calcium and magnesium (Siddiqi, 2007). Site III of river water and site VI of drain water have the highest value of 9.5 mg/l and 14.9 mg/l respectively. Municipal and industrial sewage discharges and agricultural runoff are the familiar sources of potassium in river water (Skowron *et al.*, 2018).

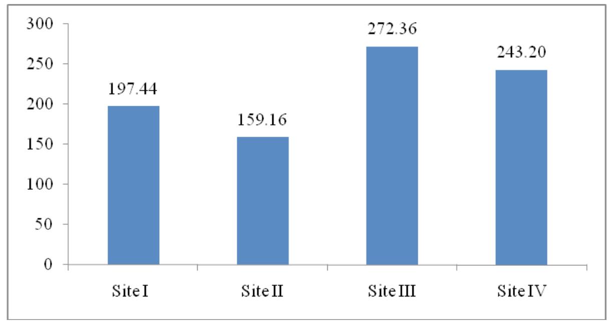


**Fig. 3.** Graphical representation of Water Quality Index v Value

*Site I (Khurai Heinoumakhong), Site II (Kongpal Kshetri Leikai), Site III (Kongba Nandeibam Leikai), Site IV (Kyamgei).

Sulphate can be naturally occurring from breakdown of leaves, organisms that fall into a stream or the result of municipal, agriculture and industrial discharges. Site II of river water and site VI of drain water have the highest sulphate content of 28.16 mg/l and 41.14 mg/l respectively.

Inorganic phosphate is one of a major component of phosphorus and is an essential nutrient for plants and animals, but excessive phosphorus in surface water can cause explosive growth of aquatic plants and algae (EPA). Site II of river water and site VII of drain water have the highest value of inorganic phosphate 1.689 mg/l and 2.600 mg/l respectively. This leads to eutrophication and unwanted plant cover on the river and eventually there was less DO, higher BOD, COD and loss of aquatic lives.

The observed range of water quality index values (Figure 3) of Kongba River is 159.16 to 272.36 by the Arithmetic Mean method. Maximum WQI value of 272.36 was recorded at Site III (Kongba Nandeibam Leikai), which can be stated as unfit for drinking consumption. Lowest WQI value of 159.16 was recorded from Site II (Kongpal Kshetri Leikai). The water quality index values obtained for the river indicates very poor water quality which is not at all recommended for drinking purposes. The water quality deterioration may be attributed to various anthropogenic activities occurring along the Kongba River.

## CONCLUSION

Application of Water Quality Index in this study has been found useful in assessing the overall quality of river water. Water Quality Index of Kongba River was calculated from various physico-chemical parameters in order to evaluate the suitability of the water for various purposes. The index values clearly showed the status of Kongba river isunsuitable for drinking water purposes and there is need for regular monitoring of water quality in order to detect major changes in physico-chemical parameters. This will help very much in saving this river from pollution effects and make the water body more suitable for daily use by the nearby people.

Further seasonal studies on the water quality of the river will supplement the present findings and give a clear status of the pollution level of the Kongba River which is a source of water for many of the residents.

## ACKNOWLEDGMENT

The authors are very grateful to Dr. Manichandra Sanoujam for providing Kongba river information, Athokpam Sonia Devi for sketching sampling site map and Shougrakpam Poireiton for assisting in calculation of water quality index.

### Conflict of Interest

The authors declare no conflict of interest.

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