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Assessment of Water Quality Index of Nambol River, Manipur, India

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Abstract:
Water Quality Index (WQI) Nambol River was analysed from July 2014 to January 2015 based on various physicochemical parameters obtained during this period. Nambol river flows through the small town of Nambol in Bishnupur district, Manipur and drains into the Loktak Lake which is included in Ramsar site. The water quality of this river has been severely affected while passing through Nambol town due to various anthropogenic activities. The physico-chemical parameter of water such as water temperature, free Carbondioxide, Dissolved Oxygen, Alkalinity, pH, Turbidity, BOD, Ammonia, Phosphate, and some metal elements were analysed. Water samples were collected from four sampling sites. The WQI value for these samples ranges from 67.878-85.276. The highest WQI value of 85.276 was recorded from Site IV which shows very poor water quality. The analysis indicates that the water is nearly polluted and not suitable for human consumption. Thus, river needs treatment so as to conserve this water body from future contamination and pollution. These findings have been discussed in the light of recent published literature.

Keywords: Manipur, Nambol River, Physico-chemical Properties, Water Quality Index.

1.0 Introduction:

Riverine system comprises both main course and tributaries, carrying the one way flow of sediment load of dissolved matter and anthropogenic sources (Rani *et al.,* 2011). River also serves for domestic, industrial and agricultural disposal, transportation, getting food resources and for recreational activities (Dhote and Dixit, 2011). Increases in use of chemical fertilizer and pesticides in agriculture are due to industrialization which causes various aquatic environmental pollution and lead to depletion of water quality (Khan *et al.,* 2012). Water quality has direct relation with aquatic productivity (Shrestha and Kazama, 2007). Maximum productivity depends on optimum level of physicochemical parameters (Muniyan and Ambedkar, 2011). The first WQI was proposed by (Horton 1965). WQI involves integration of water quality variables in order to express the quality of water into information that is understandable and usable by the general public. One of the most effective ways to communicate water quality information to public is Water Quality Index (WQI). Quality of water is defined in terms of its physical, chemical, and biological parameters (Almeida, 2007). A great deal of consideration has been given up to the development of index methods. It provides valuable information depicting the overall water quality status which will be of great help for the selection of appropriate water treatment technique to meet the concerned issues. Nambol river has its origin in Kangchup hills, Senapati district. Then it passes through Imphal west district, most densely populated district of Imphal valley and enters Nambol Municipal Township. It is a major source of water supply for Nambol town for domestic uses, drinking water, fishery and agricultural purposes. It finally drains into Loktak Lake (a Ramsar site) at Yangoi Karong. Yangoi Karong is a place where three river of Manipur meets i.e. Imphal River, Nambol River and Nambul River.

Based on importance of this freshwater body towards human livelihood, aquatic biodiversity, aquaculture, agriculture assessment of water quality index is very much required. Previous assessment of water quality of Nambol River has been carried out by (Suma and Rajeshwari, 2013), which is limited to analysis of physicochemical parameters only. Hence, assessment of WQI of Nambol River based on the values of water quality index is extremely necessary because of the rise in various anthropogenic activities and also this analysis will be of great help in future planning and implementation of water management programmes.

The main objectives of the current study is to assess and evaluate Water Quality Index (WQI) based on physicochemical parameters, to envisage the local people towards proper management of water resources and to develop a baseline data which will help in future water management and conservation policies.

2.0 Material and Method:

Present work was divided into three parts as initial pre – field survey was carried out for identifying water collection sampling stations, secondly as field work, water samples were collected from identify sampling station and lastly as post field interpretation, collected samples were analysed in laboratory and compilation of data were obtained from sample analysis.

2.1 Sampling Sites:

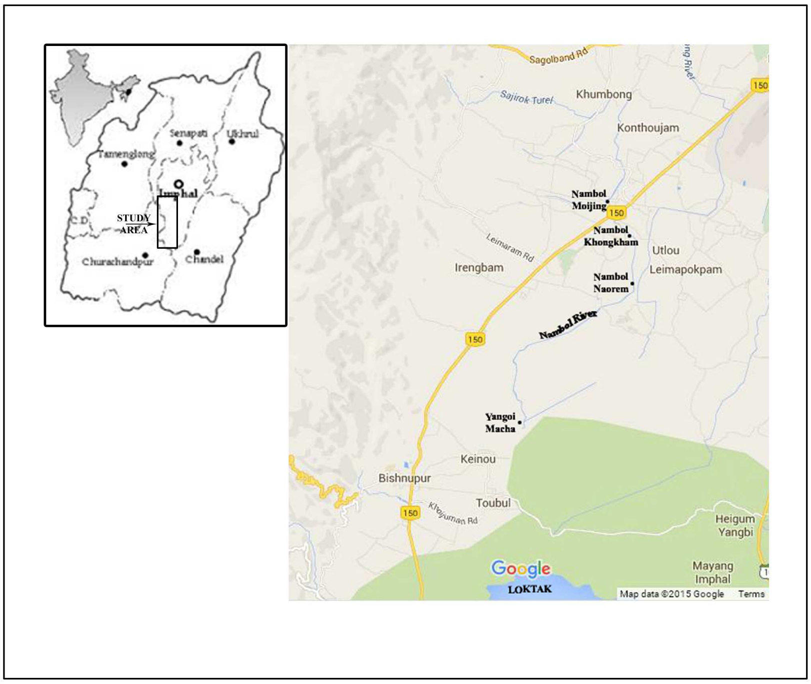

Fig. a: Location of Sampling Sites *(Source: Google Map)*

Table 1: Water sampling sites of Nambol River

Sampling sites	Latitude	Longitude
Site I Nambol Moijing	$24^0$43’3.72”	$93^0$50’4.3”
Site II Nambol Naorem	$24^0$41’18.8”	$93^0$49’43.6”
Site III Nambol Kongkham	$24^0$42’56.8”	$93^0$50’8.4”
Site IV Yangoi Macha	$24^0$37’9.9”	$93^0$48’12.5”

Water samples were collected by using plastic bottle from study site of Nambol River. Parameter like water temperature was taken on the spot using digital thermometer. p^H of water was measured by pH meter (Systronic). Turbidity or transparency of water taken by turbidity meter. Free CO_2, total alkalinity, BOD and total hardness were determined by titration method (APHA, 2005). The Dissolved Oxygen determination was done by Wrinkler’s method with Azide modification (APHA, 2005). The elements like calcium, magnesium and chloride were analysed by titration method (APHA, 2005). The elements like sodium and potassium were analysed by flame photometer and the elements like phosphate and ammonium were analysed by MColortest™.

2.2 Calculation of Water Quality Index (WQI):

In this current study, Water Quality Index (WQI) was calculated by using the Weighted Arithmetic Water Quality Index method (Cude, C., 2001). Recently, (Khwakaram 2012) modified this methodology in which different water quality parameters are multiplied by a weighing factor and are then aggregated using simple arithmetic mean. 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 = Actual value of the water quality parameter obtained from analysis,

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.

Finally, the overall WQI was calculated by aggregating the quality rating with the unit weight linearly by using the following equation:

WQI = ∑QiWi / ∑Wi

Where, Qi = Quality rating

Wi = Relative (Unit) Weight.

In this study, water quality rating was categorised according to Shweta Tyagi *et al.*, (2013), based on Weight Arithmetic Water Quality Index method:

Table 2: Rate of water quality index

Water Quality Index Value	Rating of water quality	Grading
0 – 25	Excellent	A
26 – 50	Good	B
51 – 70	Poor	C
76 – 100	Very Poor	D
Above 100	Unsuitable for drinking purpose	E

3.0 Results and Discussion:

The results of the physico-chemical properties are given in Table no. 3, 4, 5 and 6.

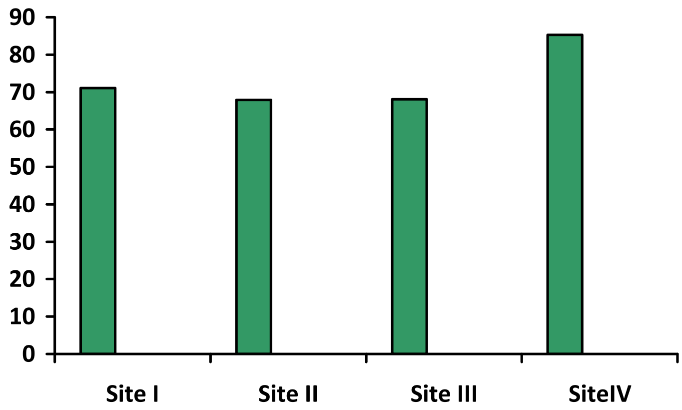

Fig. b: Graphical presentation of Water Quality Index value

**Site I = Nambol Moijing; Site II = Nambol Naorem; Site III = Nambol Kongkham; Site IV = Yangoi Macha, Toubul*

During the study period the water temperature of the river was 14.2°C to 21.2°C. The P^H range was found 6.8-7.8. The DO was recorded 3.4-9.4 ppm. Turbidity value during the study period was found to be nil. Free CO2 was recorded 1.1 – 2.9 mg/l. The total alkalinity was recorded 7 – 30 mg/l. The total hardness of the river ranged between 28 – 52 mg/l. The BOD ranged between 6.9-11.3 mg/l. The concentration of calcium ranged between 5.6 – 12.8 mg/l. The magnesium ranged between 4.7 – 10.29 mg/l during the study period. The value of Na ranged between 4–6 mg/l. Potassium content in water ranged between 1 – 5 mg /l. The chloride ranged between 0 – 25.56 mg/l. The ammonia ranged between 0.16 – 0.47 mg/l. The phosphate ranged between 0.25 – 0.50 mg/l.

The water temperature is one of the most important parameters that influence almost all the physical, chemical and the biological properties of water. The minimum value of 14.2°C was recorded during December at Site I and the highest value 21.2°C recorded during August at Site II. The minimum value of water temperature was due to atmospheric temperature. The fluctuation in river water temperature depends on the seasons and geographical area, sampling time and temperature of the stream, (Ahipathy, 2006). P^H is important water quality used to determine the acidity and alkalinity of a solution. The value ranged from 6.8 to 7.6 during the period and was within the permissible limit prescribed by W.H.O. P^H is an important parameter in water body as most of the organisms adapted to an average pH (Mini *et al.*, 2003). P^H value of 6.9 to 8.3 was recorded in Lake Pichhola (Sharma *et al.,* 2011). P^H range from 6-8 is generally found in natural water (Thakre *et al.,* 2010).

Dissolve oxygen is important parameters of aquatic ecosystem and effects on the physical and biological process of water. The oxygen acts as indicators of planktonic development and plays a significant role in proper growth of aquatic life like fishes. The minimum 3.4 ppm was recorded at Site I during January 2015 and maximum 9.4 ppm was recorded during October 2014 at Site III. However the DO was lower than 5 ppm. Lower DO content was observed in the study Site IV and Site I. The variation in DO might be due to temperature, photosynthesis, respiration, aeration, organic waste and sediment concentration (Budget *et al.,* 1985). Similar value of 3.10-5.20 mg/l was recorded (Yisa and Jimoh, 2010). Aquatic algae are the main producers of O_2 and important user of CO2. Turbidity in water is caused by suspended and colloidal matter such as clay, silts, finely divided organic and inorganic matter, plankton and other microscopic organisms. Turbidity value during the study period was found to be nil due to settle down of sediments and flow less of water current in the river. CO2 is useful for the photosynthetic activities of plants and the high range of CO2 is present in polluted water. The maximum value 2.9 mg/l was recorded at Site I during winter season may be due to lack of photosynthetic rate by aquatic plants and abundance of phytoplankton and the minimum value 1.1 mg/l at Site III during winter season may due to less abundance of aquatic organisms.

Alkalinity of water body is a measure of its capacity to neutralize acid to a designated pH (APHA, 1998 and Edokpya *et al.*, 2005). The maximum value of 30 mg/l was found at Site III during the month of January 2015. The high alkalinity may be high concentration of domestic sewage and consumption of fertilizers in agriculture. Alkalinity recommended for plankton production for fish culture is best between 20 – 50 mg/l (Boyd, 1982). For domestic use, desirable alkalinity is less than 100 ppm (Neerja *et al.,* 2012). Total hardness water increases the boiling point and reduces the formation lather (Trivedy and Goel 1986). During the study period total hardness was found between 30-48 mg/l. The lower value may be due to decreased of organic decomposition. The high value may be due to anthropogenic activities (Suma and Rajeshwari, 2013*)*. The content of calcium and magnesium cause hardness of water. WHO specified the total hardness to be within 500mg/l. BOD is the amount of oxygen required by bacteria while stabilizing decomposable organic matter under aerobic condition. The maximum value of BOD 11.3 mg/l was recorded at Site IV during Aug 2014 and the lowest value 7.0 mg/l was recorded at Site III during Jan 2015. The higher value in Aug may be due to attribution of maximum biological activity at high temperature and lowest in winter indicates lower biological activity. Calcium is one of the most abundant elements in the natural water. Calcium concentration was found between 5.6-12.8 mg/l. The maximum value was found at Site II. The value may be increased due to high temperature, low level of water and domestic waste of human in the water (Singh and Balasingh, 2011).

Magnesium adds hardness of water with calcium. The specified concentration for drinking water is 50 mg/l. During the study period the Mg concentration was 5.27-10.4 mg/l. The high value at Site I may be due to domestic sewage, as river passes the Nambol town. Similar value of 1.6-16.2 mg/l was recorded by (Shivhare *et al.,* 2014). The principal sources of Mg in the natural water are various kinds of rocks. Sewage and industrial waste are also important in contribution of Mg. Mg is non-toxic at the concentration generally met with in natural water. Sodium is an important naturally occurring cation. Na during the study period was recorded between 4-6 mg/l. Sodium value was lower than prescribed by WHO and ISI. Na salt is highly soluble in water and unlike Ca and Mg there are no precipitating reaction to reduce its concentration. The concentration of high quality of Na in water also leads to salty taste and inconsumable for human.

Potassium is the fourth naturally occurring cation in fresh water ecosystem and is always found lesser value than sodium, calcium and magnesium (Siddiqui, 2007). During study period the Potassium concentration was 1-5 mg/l. The maximum was found at Site I and the minimum at Site III. Chloride is an indicator of organic pollution in fresh water. Concentration of chloride during the study period was recorded 0-14.2 mg/l. the maximum value was recorded at Site II and Site IV. The value is less than recommended concentration which indicates the low pollution of the water. Chloride value 200-500 mg/l are recommended to be polluted (WHO, 1993). The rate of chloride increases the eutrophication which may be due to industrial and domestic disposal (Naz, 2014).

The main source of ammonia is the ammonification of organic matter. Sewage has large quantities of nitrogenous matter and its disposal increase the ammonia content of the water. Ammonia in higher concentration is harmful to fish and other biota. It is also toxic to man at higher concentration. The toxicity of ammonia increases with pH because at higher pH most of the ammonia remains in the gaseous form (Trivedy and Goel, 1984). The value of ammonia recorded during the study period was 0.15-0.47 mg/l. Ammonia is the by-product from protein metabolism excreted by fish and bacterial decomposition of organic matter (Bhatnagar and Devi, 2013). High value of ammonia may be due to ammonification of aquatic organism, sewage disposal and agricultural fertilizers. Phosphate is the first limiting nutrients for plants in the fresh water (Stickney, 2005). The value of phosphate during the study period was 1-5 mg/l which is within the permissible limit. It regulates the phytoplankton production in presence of nitrogen. Increase in phosphate was mainly by flood washing and mixing of fertilizers from near the agricultural land and it was also reported by (Sharma and Sharang 2004). Phosphate is a major nutrient regarding the growth and production of phytoplankton and its concentration and can also use to predict the total biomass of phytoplankton (Jacob *et al.,* 2008). Increase phosphate concentration also produced eutrophication and bloom formation (Khan and Siddique, 1974). The amount of phosphorus liberate into the water can increase the rate of phosphate.

3.1. Assessment of Water Quality Index:

The observed range of water quality index values of Nambol River is 67.878 to 85.276 by the Arithmetic Mean method. Maximum WQI value of 85.276 was recorded at Site IV (Yangoi Macha, Toubul), which can be stated as very poor water quality. Lowest WQI value of 67.87 was recorded from Site I (Nambol Naorem). None of this water quality index values indicate good water quality. All of this WQI values shows poor water quality and this may be due to various anthropogenic activities occurring along the Nambol River when it enters the municipal township area.

Table 3: Water Parameters of Nambol River

Parameters	Sampling Sites	Range Value	Mean ± SD*
Temperature (^{o}C)	Site I	14.2 – 18.4	16.4 ± 1.59
	Site II	20.1 – 21.2	20.57 ± 0.43
	Site III	16.2 – 20.2	18.2 ± 1.67
	Site IV	19.8 – 20.4	20.25 ± 0.47
Turbidity (NTU)	Site I	Nil	Nil
	Site II		
	Site III		
	Site IV		
pH	Site I	7.1 – 7.6	7.25 ± 0.18
	Site II	6.8 – 7.1	7.17 ± 0.24
	Site III	7.1 – 7.6	7.27 ± 0.17
	Site IV	7.2 – 7.5	7.37 ± 0.11
Dissolved Oxygen (mg/l)	Site I	3.4 – 9.2	6.35 ± 1.95
	Site II	6.8 – 7.4	7.34 ± 0.43
	Site III	5.4 – 7.0	6.58 ± 1.35
	Site IV	4.0 – 6.3	5.0 ± 0.84
Free CO_2 (mg/l)	Site I	1.1 – 2.9	1.77 ± 0.67
	Site II	1.1 – 2.7	1.84 ± 0.55
	Site III	1.1 – 2.2	1.7 ± 0.50
	Site IV	2.1 – 2.7	2.24 ± 0.20
Alkalinity (mg/l)	Site I	20 – 27	21.95 ± 3.11
	Site II	15 – 27	19.61 ± 4.28
	Site III	20 – 30	22.55 ± 4.15
	Site IV	11.1 – 24	14.17 ± 4.50
Total Hardness (mg/l)	Site I	34 – 52	43.28 ± 8.30
	Site II	32 – 46	40.0± 6.19
	Site III	30 – 48	40.28 ± 7.93
	Site IV	30 – 48	40.42 ± 8.07
BOD	Site I	7.8 – 9.1	8.27 ± 0.55
	Site II	7.0 – 8.1	7.47 ± 0.45
	Site III	6.9 – 8.4	7.77 ± 0.55
	Site IV	9.7 – 11.3	10.22 ± 0.60
Phosphate (mg/l)	Site I	0.23 – 0.25	0.24 ± 0.007
	Site II	0.23 – 0.25	0.24 ± 0.007
	Site III	0.24 – 0.25	0.24 ± 0.005
	Site IV	0.24 – 0.25	0.24 ±0.005

Table 4: Water Parameters of Nambol River

Parameters	Sampling Sites	Range Value	Mean ± SD
Chloride (mg/l)	Site I	Nil	Nil
	Site II	Nil	Nil
	Site III	11.6 – 14.2	13.18 ± 0.86
	Site IV	12.6 – 14.2	13.67 ± 0.69
Calcium (mg/l)	Site I	8.2 – 10.4	9.11 ± 0.67
	Site II	10 – 12.8	10.92 ± 1.14
	Site III	8.6 – 10.4	8.97 ± 0.63
	Site IV	5.6 – 10.4	8.01 ± 2.15
Magnesium (mg/l)	Site I	10.4 – 8.3	8.63 ± 1.62
	Site II	5.27 – 8.2	7.69 ± 1.07
	Site III	7.9 – 9.6	8.64 ± 1.73
	Site IV	5.5 – 9.3	8.24 ± 1.32
Sodium (mg/l)	Site I	5	5 ± 0
	Site II	5.0 – 6.0	5.65 ± 0.37
	Site III	4 – 5	4.75 ± 0.35
	Site IV	4	4 ± 0
Potassium (mg/l)	Site I	1	1 ± 0
	Site II	2	2 ± 0
	Site III	2 – 5	2.42 ± 1.13
	Site IV	2	2 ± 0
Ammonia (mg/l)	Site I	0.15 – 0.18	0.16 ± 0.01
	Site II	0.30 – 0.31	0.30 ± 0.005
	Site III	0.15 – 0.18	0.16 ± 0.015
	Site IV	0.44 – 0.47	0.45 ± 0.12

*Site I = Nambol Moijing;
Site II = Nambol Naorem;
Site III = Nambol Kongkham;
Site IV = Yangoi Macha, Toubul
*SD = Standard Deviation.

Table 5: Calculation of Water Quality Index of Sampling Stations:

Parameters	Sites	Observed Value (Va)	Standard Value (Si)	Relative Weight (Wi)	Quality Rating (Qi)	Weighted Values
pH	Site I	7,25	8.5	0.1176	16.66	1.959
	Site II	7.17	8.5	0.1176	11.33	1.332
	Site III	7.27	8.5	0.1176	18	2.11
	Site IV	7.37	8.5	0.1176	24.66	2.90
DO	Site I	6.35	5	0.2	85.93	17.186
	Site II	7.34	5	0.2	75.62	19.124
	Site III	6.58	5	0.2	83.54	16.708
	Site IV	5.0	5	0.2	100	20
Alkalinity	Site I	21.95	200	0.005	10.97	0.548
	Site II	19.61	200	0.005	9.8	0.049
	Site III	22.55	200	0.005	11.25	0.562
	Site IV	14.17	200	0.005	7.08	0.0354
BOD	Site I	8.27	5	0.2	165.4	33.08
	Site II	7.47	5	0.2	149.4	29.88
	Site III	7.77	5	0.2	155.4	31.08
	Site IV	10.22	5	0.2	204.4	40.8
Total Hardness	Site I	43.28	300	0.0033	14.41	0.0475
	Site II	40.0	300	0.0033	13.33	0.0439
	Site III	40.28	300	0.0033	13.42	0.0442
	Site IV	40.42	300	0.0033	13.47	0.0444
Calcium	Site I	9.11	75	0.0133	12.14	0.1614
	Site II	10.92	75	0.0133	14.56	0.1936
	Site III	8.97	75	0.0133	11.96	0.1590
	Site IV	8.01	75	0.0133	10.68	0.1420

Magnesium	Site I	8.63	30	0.0333	28.76	0.9577
	Site II	7.69	30	0.0333	25.63	0.8534
	Site III	8.64	30	0.0333	28.8	0.9590
	Site IV	8.24	30	0.0333	27.46	0.9144
Phosphate	Site I	0.24	5	0.2	4.8	0.096
	Site II	0.24	5	0.2	4.8	0.096
	Site III	0.24	5	0.2	4.8	0.096
	Site IV	0.24	5	0.2	4.8	0.096

Table 6: Water Quality Index value of different sampling sites

Sampling Sites	**Water Quality Index value**
Site I	71.06
Site II	67.878
Site III	68.067
Site IV	85.276

4.0 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 Nambol River was calculated from various physicochemical parameters in order to evaluate the suitability of water for various purposes. The index values clearly showed the status of Nambol river was poor and there is need for regular monitoring of water quality in order to detect major changes in physicochemical 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 rural people.

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