Research Paper

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Assessment of Water Quality Index for the Pond Water in Bhimavaram Town Andhrapradesh India

Environmental Science

KEYWORDS : Global water quality index, Drinking water quality index (DWQI), Acceptability water quality index (AWQI) and Health water quality index (HWQI) and Contamination.

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ABSTRACT

The knowledge of physico-chemical characteristics of water is essential for proper exploitation of aquatic environment. Hence physico-chemical analysis of pond water samples was carried out from six sampling locations at Bhimavaram town for the period of January to December in the year 2014. An attempt has been made to develop global water quality indexes (AWQI, HWQI and DWQI), using 13 water quality parameters (Turbidity, pH, Total Dissolved Solids, Total Hardness, Chlorides, Sulphates, Sodium, Iron, Zinc, Nitrates, Fluorides, Lead and Mercury) in the pond water sampling stations. The global water quality method was proved an east and effective method for pond water quality to assess the suitability of water for drinking purposes. Water quality provides an easy and rapid method of monitoring of the water quality. The analysis reveals that the pond water of the area needs some degree of treatment before consumption.

INTRODUCTION

Life is believed to have originated in water, and living organisms use aqueous solutions (including blood and digestive juices) as mediums for carrying out biological processes. Chemical contamination of drinking water are not felt on quick-fix bases (except nitrate), their accumulation over a long period in the body has significant health effect (Musa *et al.*, 2004) As the urbanization process continues, water pollution problems have become increasingly evident, and have led to serious ecological and environmental problems (Almasri and J.Kaluarachchi, 2004) . Owing to increasing industrialization on one hand and exploding population on the other hand the demands of water supply have increasing tremendously. Increasing population has led to the deterioration of surface and sub surface water (Dhiviyaapranavam *et al.*, 2011). Increased Urbanization and Industrialization are to blame for an increased level of trace metals, especially heavy metals, in our water ways. There are over 50 elements that can be classified as heavy metals, 17 of which are considered to be both are very toxic and relatively accessible. Toxicity levels depend on the type of metal, its Biochemical role, and the type of organisms that are exposed to it (Malleswara Rao, 2005). The healthy aquatic ecosystem is depended on the physico-chemical characteristics (Venkatesharaju *et al.*, 2010). So the quality of water may be described according to their physcio-chemical characteristics. Water quality index is one of the most effective tools to communicate information on the quality of water to the concerned citizens and policy makers (Mishra and Patel., 2001, Nai and Purohit., 2001, Singh 1922, Tiwari and Ali, 1988). The concept of WQI was developed and proposed first by Horton (1965). The use of an Index top grade water quality is a notorious among the water quality scientists. Surface water (ponds) used to be the main source of drinking water in the Bhimavaram town. People use the stagnant water bodies in the form of ponds for various purposes like drinking, irrigation, domestic use, fisheries, washing, etc. From the literature review, no one in the depth study was encountered which can holistically address the water quality status and the management of drinking water needs of Bhimavaram people. Hence a comprehensive study was contemplated with the main objective; to assess the pond water quality based on the WHO defined guidelines of the health and acceptability categories by using the UNEP developed global water quality index (UNEP, 2007) is calculated from view of the suitability for the pond water for human consumption. This study is also an important tool in the assessment of Water Quality Index

MATERIALS AND METHODS

The calculation of WQI was made by using different methods, but Scaling of global water quality index into drinking water quality index (DWQI), acceptability water quality index (AWQI) and health water quality index (HWQI) categories specified by UNEP provide an overall picture as to the quality of water. After compiling the results, the water quality indices for each sampling station were computed separately for the drinking (DWQI), acceptability (AWQI) and health (HWQI) water quality measurements by applying the Canadian water quality index model, using WHO drinking water quality also guidelines as recommended by UNEP (2007). The steps followed in the calculation of WQI are as follows.

Water quality index (WQI) Computation:

The index allows measurements of the frequency and extent in which parameters exceed their respective guidelines at each sampling station. Therefore, the index reflects the quality of water for both health and acceptability criteria, as set by the WHO. The Index was based on a combination of three factors: Scope (F_1) - the number of variables were not meeting water quality objectives, Frequency (F_2) - the number of times these objectives are not met and Amplitude (F_3) - the amount by which the objectives are not met (CCME, 2001). The index produces a number between 0 (worst water quality) and 100 (best water quality) covering five descriptive categories namely; poor, marginal, fair, good and excellent (Table -2).

$$WQI = 100 - \left\{\frac{\sqrt{F_1^2 + F_2^2 + F_3^2}}{1.732}\right\}$$

F_1 represents scope: The percentage of parameters that exceed the guidelines.

$$F_1 = \left\{\frac{\text{Failed parameters}}{\text{Total no. of parameters}}\right\} X\ 100$$

F_2 represents frequency: The percentage of individual tests within each parameter that exceeded the guidelines.

$$F_2 = \left\{\frac{\text{Failed tests}}{\text{Total no. of tests}}\right\} X\ 100$$

F_3 represents amplitude: The extent (excursion) to which the failed test exceeds the guideline. This is calculated in three stages.

First, the excursion is calculated.

$$\text{excursion} = \left\{\frac{\text{Failed test value}}{\text{Guideline value}}\right\} - 1$$

Second, the normalized sum of excursions (nse) is calculated as follows:

$$\text{nse} = \left\{\frac{\Sigma \text{ excursion}}{\text{Total no. of tests}}\right\}$$

F_3 is then calculated using a formula that scales the nse to range between 1 and 100.

$$F_3 = \left\{\frac{\text{nse}}{0.01\text{nse} + 0.01}\right\}$$

Table – 1 Water quality index labels.

Label.	Index value.	Description.
Excellent	95 – 100	All measurements are within objectives virtually all of the time.
Good	80 – 94	Conditions rarely depart from natural or desirable levels.
Fair	65 – 79	Conditions sometimes depart from natural or desirable levels.
Marginal	45 – 64	Conditions often depart from natural or desirable levels.
Poor	0 – 44	Conditions usually depart from natural or desirable levels.

Finally, to understand which parameters were contributing the most to the index, the parameters that exceeded the guidelines within each index (validation of indices) were calculated for each sampling station.

Study area

Bhimavaram town is located between 16^{o} 32' North latitude and 81^{o} 32 East longitudes and covers an area of 1111sq km with a population of 1, 42,317 as per 2001 censess. The Enamadurru drain passes through the Bhimavaram and this drain separates both 'One town' and 'Two town'. It is situated at the centre in Bhimavaram. The drain carries industrial waste from different places in and around Bhimavaram to the Bay of Bengal. There are many industrial units held in and around Bhimavaram such as Delta Paper Mills Ltd., Vendra, Pharmaceutical companies, Agro Industries, Fish and Prawn processing units and ancillary units etc., the above industrial units discharge industrial waste to Enamadurru drain. The residents along the Enamadurru drain bunds discharge their domestic waste, non-biodegradable plastic and unhygienic latrine pipes into the drain and agriculture is another major sector. A few industries are located in the vicinity of Bhimavaram. However rapid growth in the aquaculture operations and industrial development, the environment within the urban area in Bhimavaram has adversely affected.

Table 2: Details of sampling stations of the study area

S.No	Sampling Stations	Geographical Coordinates
P1	Storage Tank	N 16^{0}33'57 E 81^{0}32'58
P2	Railway Pond	N 16^{0}32'34 E 81^{0}32'35
P3	Rayalam Tank	N16^{0}32'08 E 81^{0}30'43
P4	Edward Tank	N16^{0}32'25 E 81^{0}31'25
P5	Veeramma Pond	N16^{0}32'25 E81^{0}31'54
P6	Chandra Pushkarini	N16^{0}32'24 E 81^{0}32'14

Sample analysis

Water samples from six ponds (Table -2), were collected into clean 500 ml plastic bottles during the period of January to December in 2014. The sampling bottles were cleaned with 10% of nitric acid. After the collection of samples they were labeled and brought to Andhra university laboratory. The physico-chemical parameters were determined as described by (APHA, 1998). Trace metals analysis (Iron, Zinc, Lead and Mercury) of pond water sampling sites was performed by inductively coupled plasma-mass spectrometer (ICP-MS) in the analytical laboratory of Andhra University Vishakhapatnam.

Statistical analysis

The samples were analyzed in the triplicate, Graph pad prism version 6.0. To identify the standard deviation among the different parameters were computed as well.

RESULT AND DISCUSSION

Application of WQI is a useful method in assessing the suitability of water from various beneficial uses. The water quality index values are listed in Table–3 and Fig.1. According to Health water quality index (HWQI) point of view, the pond water quality in 10% of the samples was 'marginal' whereas 50% of the samples were excellent', and 'fair' at 40% of the sampling stations, indicated that the contributed to Lead, Iron and Mercury (Table- 4). In the case of acceptability water quality index (AWQI) 'poor' conditions were observed at 50% of sampling stations followed by the 'marginal' at 50%, 'good' at 20% and 'poor' at 10% of sampling stations. The water quality of P2, P3, P6 sampling stations were severely deteriorated with respect to acceptability water quality because of excess concentration of the turbidity, TDS, total hardness chlorides, sulphates, nitrates and sodium(Table- 4) when compared to (WHO, 2004) permissible limits. The extreme values in the chemical constituents of the pond water, in this sampling station can be attributed to the soil erosion, waste discharge, urban runoff, alga growth etc. Except at p-2sampling station, all the other stations were recorded higher values of HWQI than the AWQI (Fig.1). The water quality in 80% of the samples of the study area was in better position regarding the human health aspects compared to the acceptability aspects (Table-2). The results revealed that the water quality related to acceptability aspects in the majority of the study area was degraded and have to be improved considerably even though all these aspects are not having any direct health effects. The drinking water quality indices at the study area showed the status of 'marginal' at 90% of the stations followed by 'fair' at 10%. The pond water quality of the study area showed in different trends for the acceptability, health and drinking water quality concerns (Fig.1) owing to the variation of chemical constituents. Consumers mostly rely upon their senses while assessing the quality of drinking water. The acceptance or rejection will be decided on the basis of the appearance, odour and taste of the water. Treating these parameters alone can improve the drinking water quality to the acceptability level. Overall drinking water quality (DWQI) of the study area by closely following the AWQI, revealed that the impact of acceptability parameters ranging from 42.46 (poor) to 63.27 (marginal) (Table-3). It could be concluded that the drinking water quality of the study area is strongly influenced by the acceptability parameters rather than the health parameters.

CONCLUSION

A healthy pond is a magnet for life, both above and below the surface. It is full of fish, insects, and amphibians. In this present global water quality index investigation reveal that the surface water in all six ponds can be used domestic purposes, but it is not suitable for drinking and cooking purposes. The urban aquatic ecosystems are strongly influenced by long term discharge of untreated domestic and industrial waste waters, storm water runoff and direct solid waste dumping. The present study further suggests that are regular monitoring should be done in various seasons to identify the pollution sources. Future workers

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can rely on UNEP developed water quality index as it is a cost effective and time saving for managing the water quality.

Table 3: WQI and designation of the selected pond water sampling stations of the study area

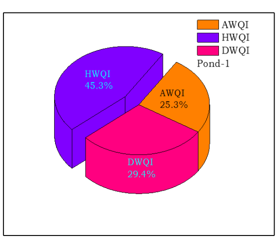
Pond water stations	WQI	Index valu	Label.
P-1	AWQI	55.82	MARGINAL
	HWQI	100	Excellent
	DWQI	64.92	MARGINAL
P-2	AWQI	44.60	POOR
	HWQI	63.30	MARGINAL
	DWQI	49.00	MARGINAL
P-3	AWQI	42.46	POOR
	HWQI	79.58699	FAIR
	DWQI	51.71	MARGINAL
P-4	AWQI	45.05	MARGINAL
	HWQI	100	EXCELLENT
	DWQI	59.41	MARGINAL
P-5	AWQI	63.27	MARGINAL
	HWQI	100	EXCELLENT
	DWQI	72.77	FAIR
P-6	AWQI	44.40	POOR
	HWQI	79.58698669	FAIR
	DWQI	53.72	MARGINAL

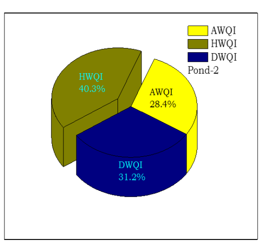
AWQI-Acceptability water quality index
HWQI-Health water quality index
DWQI-Drinking water quality index

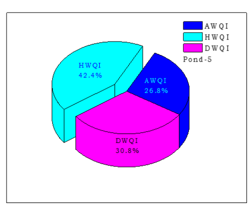
Table 4: Analysis the data of Physico-chemical and trace metals in pond water samples

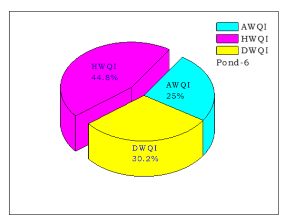
Pond water		Turbidity (NTU)	pH	Total Dissolved Solids, ppm.	Total Hardness, ppm (as CaCO3).	Chlorides, ppm	Sulphates, ppm	Sodium (as Na) ppm	Iron (as Fe), ppm.	Zinc, ppm.	Nitrates, ppm	Fluorides, ppm	Lead (as Pb), ppm	Mercury(as Hg), ppm
P-1	Range	27-42	7.2-7.74	131-143	647-1002	18.09-22	257-288	20-22	0-0.047	0-0.002	25-39	0.26-0.28	0-0.003	0
	Average	31	7.486	136.1667	845	20.348	270.666	20.75	0.047	0.002	30.333	0.273	0.003	0
	Std.Deviation	5.513	0.218	4.355	140.672	1.335	12.738	0.734	7.6012E-18	0	5.163	0.008	4.75E-19	0
P-2	Range	30-40	7.2-8	343-403	629-876	127.9-678	260-350	200-221	0-0.019	0-0.454	42-58	0.1-0.2	0-0.004	0-0.002
	Average	34.833	7.38	374.333	756.5	319.486	300.833	206.166	0.019	0.454	48.833	0.15	0.004	0.002
	Std.Deviation	4.119	0.312	24.130	89.527	202.016	36.301	7.833	0	0	6.997	0.054	0	0
P-3	Range	22-39	7.31-7.45	315-390	624-836	327-470	256-420	212-300	0-0.016	0.001-0.454	29-39	0.3-0.6	0-0.002	0-0.002
	Average	33.833	7.378	357.833	700.666	374.5	324.166	239.5	0.016	0.378	33.333	0.5	0.002	0.002
	Std.Deviation	6.645	0.054	24.457	82.587	63.203	70.069	33.206	0	0.184	3.777	0.126	0	0
P-4	Range	38-45	7.18-8	120-146	447-649	540-823	229-340	227-336	0-0.006	0-0.028	25-48	0.1-0.8	0-0.004	0
	Average	40.666	7.4	133.833	536.666	698.333	293.833	278.5	0.006	0.028	36.333	0.408	0.004	0
	Std.Deviation	2.503	0.304	10.703	80.896	99.026	39.554	54.562	9.5E-19	0	9.933	0.283	0	0
P-5	Range	28-37	7.2-7.46	130-146	389-489	39-46	259-350	18-20.38	0-0.006	0-0.028	27-39	0.19-0.5	0-0.004	0
	Average	32.166	7.295	139.166	432.666	41.515	304.833	19.485	0.006	0.028	30.833	0.316	0.004	0
	Std.Deviation	3.125	0.092	6.524	35.612	3.132	30.622	1.135	9.5E-19	0	4.355	0.113	0	0
P-6	Range	28-30	7.45-8	885-1607	1000-1348	110-140	259-380	340-409	0-0.119	0.0.009	4-7.8	0.5-0.56	0.015-0.02	0
	Average	29	7.745	1162.166	1111.666	127	327.333	384.333	0.119	0.009	6.863	0.521	0.018	0
	Std.Deviation	0.894	0.241	293.018	165.342	10.488	53.768	24.138	0	0	1.427	0.024	0.002	0

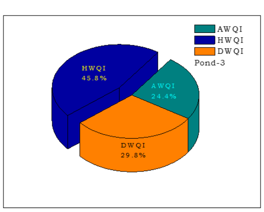
Concentration of all parameters are expressed in mg/L except pH, Turbidity (NTU), EC (μS/ho), Iron(ppm), Zinc(ppm), Lead(ppm) and Mercury(ppm) Std.Deviation: Standard Deviation











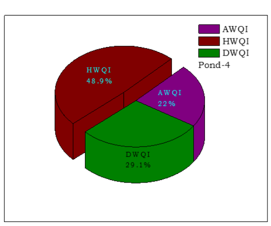


Fig.1: Graphical representation of Water Quality Indexes (AWQI, HWQI and DWQI) in the pond water samples

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