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EVALUATION OF WATER QUALITY STATUS OF AMEENPUR LAKE, HYDERABAD, TELANGANA, INDIA USING WATER QUALITY INDEX (WQI) AND GEO-SPATIAL TECHNOLOGY

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ABSTRACT

The present study was carried out to evaluate the water quality of the Biodiversity Heritage Site i.e., Ameenpur Lake (Telangana, India) using Water Quality Index (WQI) and spatial distribution technique. The water samples were collected during Pre-Monsoon, Monsoon and Post-Monsoon seasons of the year 2019-20 and analysed for physico-chemical parameters as per the American Public Health Association (APHA) standard methods for water and wastewater treatment. The WQI were calculated by using the standard method of Weighted Arithmetic Water Quality Index (WAWQI) and National Sanitation Foundation Water Quality Index (NSFWQI). The WAWQI and NSFWQI methods indicated that overall water quality of the lake was found to be poor in all the seasons. According to the WAWQI map, majority of the samples were found be in the poor water quality in all the three seasons and according to the NSFWQI map, all the samples were found to be bad in condition in all the seasons. The same is represented in the spatial distribution maps. The decline in the quality of lake water is due to various anthropogenic activities like enrichment through surface and agricultural runoff and also due to discharge of untreated sewage and industrial effluents.

Keywords: Ameenpur Lake, Biodiversity Heritage Site, Water Quality Index, Geo-spatial tools, Spatial Distribution.

INTRODUCTION

Surface waters play a crucial role both in social and economic development, especially when it comes to Freshwater lakes and rivers. They are the most beneficial resources to the society in many ways such as agriculture; fishing, as a drinking water source, for industrialization and most importantly support rich biodiversity. A lake is a watershed area in which its quality depends upon every component of that ecosystem (Indra 2006). Its quality depends on the Topography of the surrounding area, soil type, geology and vegetation as it determines the kind of materials entering into lake (Dong *et al.,* 2010). In the last few decades, the haphazard population increase, urbanization and industrial development are the major reasons for deteriorating both the rural and urban water quality and ultimately affecting the aquatic ecosystem. Under this pressure with worldwide environmental concerns most of the urban and rural lakes have vanished (Iscen *et al.,* 2008; Prasanna *et al.,* 2010). Once the groundwater and surface water quality is contaminated, its quality can't be restored by stopping the pollutants from the source (Ouyang, Y *et al.,* 2006). According to the WHO, CPCB, BIS and ICMR about 70% of the India's water quality is polluted due to discharge of industrial effluents and sewage wastewater making the natural stream unfit for consumption (Nida Rizvi 2016). Evaluating the water quality is crucial before its use for various purposes such as drinking, agricultural, fishing, recreational and industrial use. Hence monitoring of surface water quality has become indispensable (Sashikkumar M.C. 2013). It therefore becomes imperative to regularly monitor quality of surface water resources and to device ways and mean to protect it.

Water quality index (WQI) is considered one of the best tools to provide information on the quality of water to the concerned citizens and policy makers. This method also gives an idea about the overall quality of water to the concern policy makers (Asadi *et al.,* 2007). For both assessment and management of surface water it thus becomes an important tool as assessment of water quality helps in knowing the water suitability for various purposes. In 1970's the WQI was developed to monitor water quality changes which was proposed by Horton (1965) and Brown *et al.,* (1970). Later Bhargava (1983 a,b,c) introduced the water quality index concept in India and gave an index scale ranging from 0 to 100 for highly polluted to unpolluted water.

The prime objective of the index is to turn the different water quality parameters into information, which is comprehensible and usable by the layman (Brown *et al.,* 1970 and Boyacioglu H. 2007). Using the biological, chemical and physical properties, the WQI is usually illustrated and based on these properties; the quality of water can be expressed via a numerical index (i.e. Water Quality Index, WQI) by combining measurements of selected water quality variables (Horton 1965). The index is important in evaluating the water quality of different

sources and in observing the changes in the water quality as a function of time and other influencing factors (Sarkar and Abbasi 2006). Numerous water quality index guideline are used worldwide viz., National Sanitation Foundation Water Quality Index (NSFWQI), Canadian Council of Ministers of the Environment Water Quality Index (CCMEWQI), British Columbia Water Quality Index (BCWQI), Oregon Water Quality Index (OWQI), Weighted Arithmetic Water Quality index (WAWQI) for the assessment of Water Quality Index (Brown *et al.,* 1970; BCMOELP, 1965; CCME, 2001, Cude, 2001).

The present study was aimed to assess the water quality using the water quality index and spatial distribution zone maps of the water quality index were created to understand the water quality better. Water Quality Index was assessed by using physico-chemical parameters such as pH (units), Turbidity (NTU), Total Dissolved Solid (mg L^{-1}), Alkalinity (mg L^{-1}), Total Hardness (mg L^{-1}), Calcium (mg L^{-1}), Magnesium (mg L^{-1}), Nitrate (mg L^{-1}), Sulphate (mg L^{-1}), Nitrate (mg L^{-1}), Phosphate (mg L^{-1}), Fluorides (mg L^{-1}), Chloride (mg L^{-1}), Dissolved Oxygen, and Biological Oxygen Demand (mg L^{-1}),. The water quality index and the spatial distribution map were analyzed for 10 different locations of the study area. The approaches utilized for calculating the WQI was Weighted Arithmetic Water Quality Index (WAWQI) and National Sanitization Foundation Water Quality Index (NSFWQI). Using the IDW interpolation spatial distribution map of the Ameenpur Lake, Telangana were created for both the indexes.

MATERIALS AND METHODS

Background and Study Area

Ameenpur Lake is on the north western fringes of Hyderabad (17° 31.198'N, 78° 19.524'E) situated in Patancheru Mandal, Sangareddy District, Telangana State, India, covering an area of 93.15 Acres (0.38 Sq. km) (Sy.No-231- Shikam Land) and is a man-made lake that was declared as the Biodiversity Heritage Site in 2016 by the National Biodiversity Authority. It is the only urban lake to be declared as a Biodiversity Heritage Site. Even though with small size (93.15 Acres/0.38 Sq. km) and unpredictable nature, this Ameenpur Lake is known to harbour novel, rare and/or threatened fauna and their resting stages, thus acting as "local nature reserve" or "hotspot". G.Sailu et al (2017) has reported a total of 364 faunal components. The key species recorded by them are namely Oriental Darter (Anhinga melanogaster), Pallid Harrier (Circus macrourus), Black-tailed Godwit (Limosa limosa), Painted Stork (Mycteria leucocephala), River Tern (Sterna aurantia) and Black-headed Ibis (Threskiornis melanocephalus), Greater Spotted Eagle (Clanga clanga), Egyptian Vulture (Neophron percnopterus), Greater Flamingo (Phoenicopterus roseus), Northern Pintail (Anas acuta), Garganey (Anas querquedula), Indian Black Turtle (Melanochelys trijuga), Treutleri's Gecko Hemidactylus treutleri Painted Kaloula (Uperdon taprobanicus) and Marbled Narrow-Mouthed Frog (Uperdon variegates).

On one side the rich biodiversity that has brought it the status of a Biodiversity Heritage Site and on the other side there has been deterioration in the water quality of Ameenpur Lake. Both natural and man-made alterations are affecting the quality and quantity of the lake. Major factors like urbanization, domestic sewage discharge, untreated industrial effluents, religious and cultural activities due to the presences of temples on all sides of the lake, fishing and improper agricultural practices can disturb or disrupt aquatic ecosystems leading to eutrophication of lake, which in turn interferes with most of its beneficial uses like effecting the natural ecosystem, biodiversity and even the portability of water (Dr. Durai Arulneyam and Dr. R. Premsudha, 2018). It is now facing a renewed threat from revellers and encroachers. The end of COVID-19 lockdown in 2020 has brought new threats to the lake like loud noise due to vehicles parking and partying around the lake thereby bringing lots of waste to the lake impacting the bird population of the lake.

Sampling and Analysis

Collection, Stabilization, Storage of Samples and transportation to laboratory were conducted according to the recommendations of Central Pollution Control Board (CPCB, 2008). All the water samples were taken at a depth below 0.5 m from the surface. They were collected from 10 different locations during pre-monsoon (May), monsoon (September) season in the year 2019, and for post monsoon (January) season in the year 2020 (S1 to S10) (Table 1). The assessment of fifteen physicochemical parameter like as pH (units), Nitrate (mg L^{-1}), Dissolved Oxygen, Phosphate (mg L^{-1}), Biological Oxygen Demand (mg L^{-1}), Turbidity (NTU), Total Dissolved Solid (mg L^{-1}), Alkalinity (mg L^{-1}), Total Hardness (mg L^{-1}), Calcium (mg L^{-1}), Magnesium (mg L^{-1}), Sulphate (mg L^{-1}), Nitrate (mg L^{-1}), Fluorides (mg L^{-1}) and Chloride (mg L^{-1}) was carried out as per the APHA standard methods.

Calculation of Water Quality Index

In various literatures (Horton, 1965; Landwehr and Deininger, 1976; Brown *et al.,* 1972; Steinhart *et al.,* 1982; Zandbergen and Hall, 1988; Cude, 2001a, b; Canadian Council of Ministers of the Environment (CCME), 2005; Bhargava, 1983 a, b, c) different methods has been used for the calculation of WQI by comparing the physico-chemical and biological parameters. Among the different methods Weighted Arithmetic Water Quality Index (WAWQI) and National Sanitation Foundation Water Quality Index (NSFWQI) were adopted for calculation of WQI.

Table1: Sampling Locations Points of Ameenpur Lake, Telangana

S.no	Sample ID	Location Name	Latitude	Longitude
1	S1	Sai Baba Temple	17.5243	78.3253
2	S2	Kattamaisamma Temple	17.5225	78.3258
3	S3	Rock Area	17.52	78.3285
4	S4	Fisherman's Point	17.5203	78.3319
5	S5	Mid Lake	17.5218	78.3316
6	S6	Bird Watching Point	17.5211	78.3344
7	S7	Renuka Temple	17.5243	78.3368
8	S8	Opp to Fisherman's Point	17.5247	78.3308
9	S9	Transformer Line	17.5253	78.3301
10	S10	Agricultural Field	17.525	78.3272

Weighted Arithmetic WQI

For the Weighted Arithmetic WQI, a set of eleven most commonly used water quality parameters namely pH (units), Total Dissolved Solid (mg L^{-1}), Alkalinity (mg L^{-1}), Total Hardness (mg L^{-1}), Calcium (mg L^{-1}), Magnesium (mg L^{-1}), Sulphate (mg L^{-1}), Nitrate (mg L^{-1}), Fluorides (mg L^{-1}) and Chloride (mg L^{-1}) were used for the calculation of WAWQI. The formula used for calculating WAWQI was

$$WAWQI = \frac{\sum_{i=1}^{i=n} QiWi}{\sum Wi}$$

Where,

W_i = Unit weight for each water quality parameter;
Q_i = The quality rating scale for each parameter
n = No. of water quality parameters.

Table 2: WAWQI Method Water Quality Classification (Horton, 1965 and More, 2019)

WQI Value	Water Quality Status	Purpose
0-25	Excellent Water Quality	Drinking, Irrigation and Industry
26-50	Good Water Quality	Drinking, Irrigation and Industry
51-75	Poor Water Quality	Irrigation and Industry
76-100	Very Poor Water Quality	Irrigation
>100	Unsuitable for drinking and fish culture	Proper treatment required before use

The WQI was considered to assess if the water is fit for the human consumption or any other uses, and a score of 100 was taken for the maximum permissible WQI for the drinking water. Rating scale proposed was in the range of 0 – 100 and grading were proposed as a below (Table 2) (Horton, 1965).

National Sanitation Foundation Water Quality Index:

The National Sanitation Foundation WQI used seven different parameters namely Nitrate (mg L^{-1}), pH (units), Dissolved Oxygen (% saturation), Phosphate (mg L^{-1}), Biological Oxygen Demand (mg L^{-1}), Turbidity (NTU) and Total Dissolved Solid (mg L^{-1}) for the calculation of WQI. If less than 9 tests are performed, the overall WQI can be estimated by adding the results and then adjusting for the number of tests [14]. In case concentrations of some parameters are not available, first we can calculate the q- values of those parameters, the concentration of which is available and then those q- values are multiplied with their respective weighting factors. The summation of these values, divided by the summation of weighting factors of available parameters can give WQI (BASIN, 2001). The weight score (W_i) was multiplied by the Sub index value of each parameter. Sub index value for each parameter was obtained by NSF-WQI Online calculator (www.waterresearch.net) (Mirzaei et al, 2015). Finally the WQI was calculated by using following equation:

$$NSFWQI = \sum_{i=1}^{N} WiQi$$

Where,

N = number of water quality parameters;
Q_i = sub-index for i^{th} water quality parameter;
W_i = weight (in terms of importance) associated with i^{th} water quality parameter.

Table 3: NSFWQI method Water Quality Classification (Mirzaei *et al.,* 2015)

NSFWQI Value	Water Quality Status	Classification based on type of water resource usage
0-25	Very Bad	Not appropriate for any use, except to support few aquatic organisms.
26-50	Bad	Irrigation
51-70	Medium	Fishery, Animal Consumption, Can be used for Human consumption only if advance treatment is done.
71-90	Good	Fishing, Recreational (Swimming). Can be used for Human consumption only if conventional treatment is done.
91-100	Excellent	Drinking and Fishery

The spatial distribution modelling for both WAWQI and

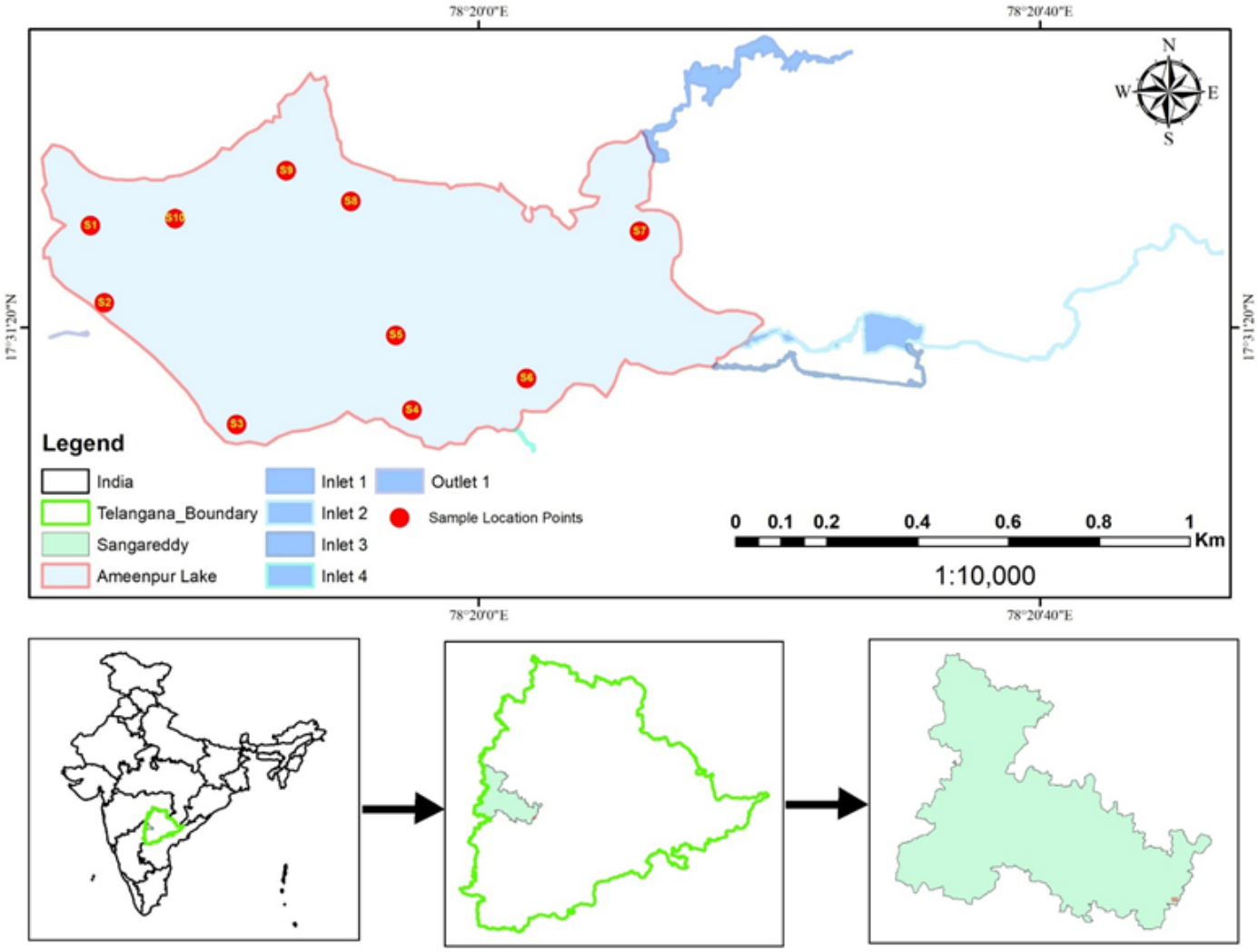

Fig 1: Study Area showing the sample location point

Fig 2: Google Earth Image of Study Area

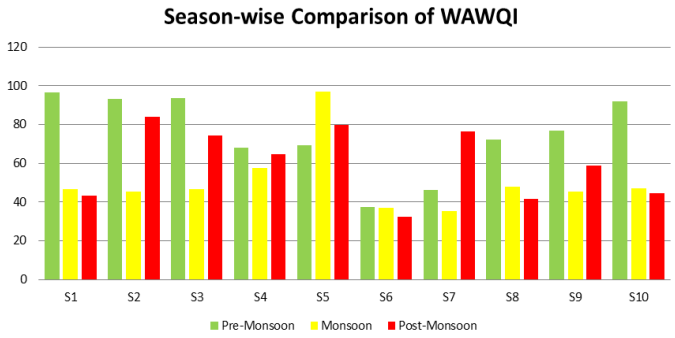

Fig 3: Graphical representation of the season-wise WAWQI

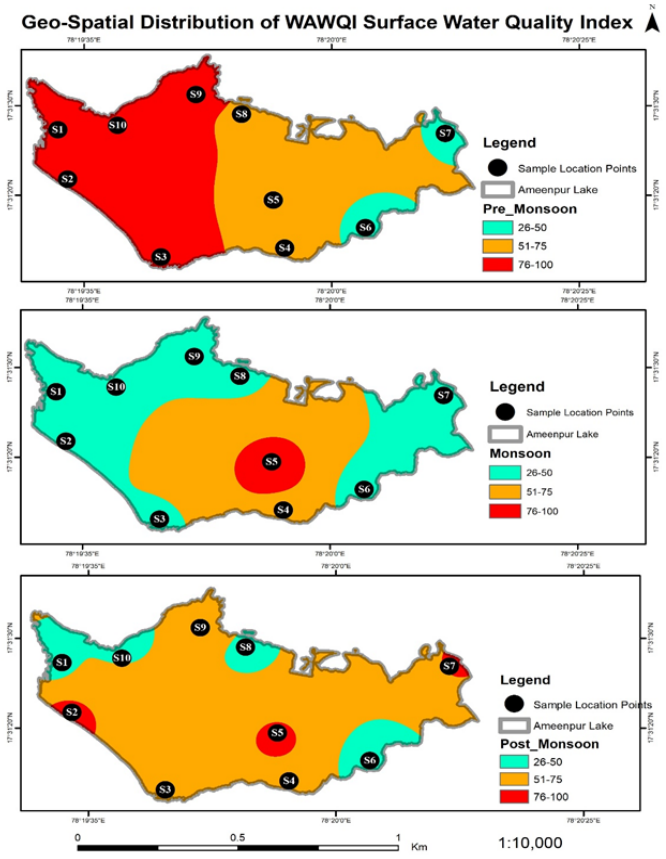

Fig 4: Season-wise Spatial Distribution Maps of WAWQI

NSFWQI water quality index has been done by using Inverse distance weighted (IDW) interpolation technique.

RESULTS AND DISCUSSION

Water Quality Index

The values for Weighted Arithmetic Water Quality index (WAWQI) map shows two classes of water quality viz. Poor: Tourmaline Green colour, Very Poor: Orange colour and Unsuitable for drinking and fish culture: Red colour.

The overall WAWQI percentage values from study area shows excellent: 0%, good: 16.6%, poor: 40%, very poor: 26.6%, and unsuitable for drinking and fish culture: 16.6%. The major part of the study area falls in the poor category during all seasons. Pre-Monsoon Samples i.e., Sites S1, S2, S3, S9 and S10 were very poor in condition; Samples S4, S5 and S8 were poor whereas sites S6 and

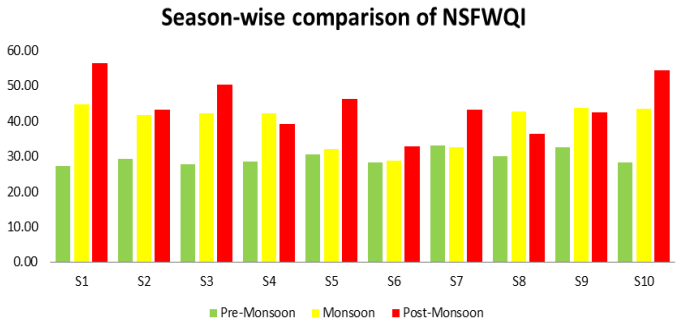

Fig 5: Graphical representation of the season-wise NSFWQI

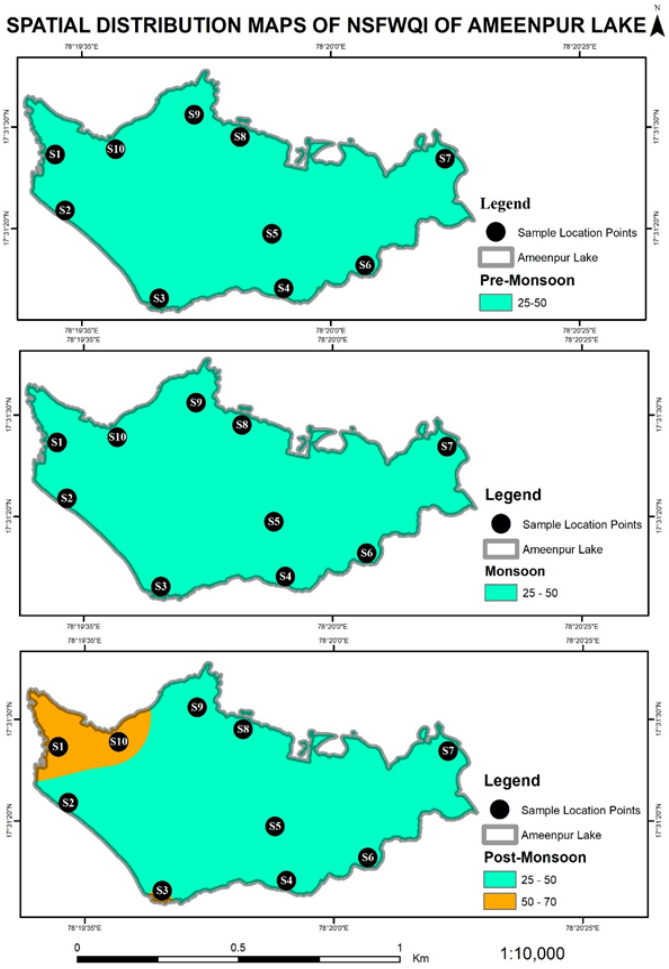

Fig 6: Season-wise Spatial Distribution Maps of WAWQI

S7 were in good category. Monsoon Samples i.e., Sites S5 was very poor in condition, Samples S4 was poor whereas others were in good category. Post-Monsoon Samples i.e., Sites S2, S5 and S7 were very poor in condition; Samples S3, S4 and S9 were poor whereas others were in good category as shown in Table 4. Whereas in Table 5 all the percentage wise WAWQI are tabulated.

The values for National Sanitation Foundation Water Quality index (NSFWQI) map also shows two classes of water quality viz. medium: Tourmaline Green colour and bad: Orange colour The Overall NSFWQI percentage values from study area shows excellent: 0%, good: 0%, medium: 30%, bad: 70%, and very bad: 0%. The major part of the study area falls in the bad category during all

seasons. All the summer and monsoon Samples were bad whereas sites S1, S3 and S10 of winter samples were in medium category and remaining all were in bad category as shown in Table 6. Whereas in Table 7 all the percentage wise NSFWQI are tabulated.

Table 4: WAWQI of the three seasons

Sample ID	WQI		
	Pre-Monsoon	Monsoon	Post-Monsoon
S1	96.35	46.61	43.19
S2	93.19	45.52	83.92
S3	93.8	46.78	74.41
S4	67.98	57.7	64.54
S5	69.33	96.82	79.97
S6	37.45	37.12	32.2
S7	46.15	35.45	76.31
S8	72.06	47.89	41.78
S9	76.77	45.51	58.96
S10	91.95	47.21	44.48
Avg	74.5	50.6	55.5

Table 5: Percent Distribution of WAWQ

WQI Value	Water Quality Status	Percentage of Samples		
		Pre-Monsoon	Monsoon	Post-Monsoon
0-25	Excellent Water Quality	0	0	0
26-50	Good Water Quality	10	20	20
51-75	Poor Water Quality	10	70	40
76-100	Very Poor Water Quality	40	0	40
>100	Unsuitable for drinking	40	10	0

Table 6: NSFWQI of the three seasons

Sample ID	NSFWQI		
	Pre-Monsoon	Monsoon	Post-Monsoon
S1	27.39	44.68	56.54
S2	29.30	41.72	43.31
S3	27.76	42.27	50.34
S4	28.45	42.28	39.22
S5	30.61	32.11	46.39
S6	28.39	28.89	32.78
S7	33.15	32.65	43.36
S8	30.08	42.76	36.39
S9	32.64	43.78	42.45
S10	28.31	43.65	54.34
Avg	29.60	39.47	44.51

Table 7: Percent Distribution of NSFWQI

NSFWQI Value	Water Quality Status	Percentage of Samples		
		Pre-Monsoon	Monsoon	Post-Monsoon
0-25	Very Bad	0	0	0
26-50	Bad	100	100	70
51-70	Medium	0	0	30
71-90	Good	0	0	0
91-100	Excellent	0	0	0

CONCLUSION

The present study carried out at the ten sample sites of the Ameenpur Lake, Telangana was to understand the spatial distribution of water quality index of all the three seasons. Using the WAQQI and NSFWQI were very useful and effective tool to know the present status of surface water quality as this would give an opportunity to the people for better use of water in the future. In the study area the WAWQI and NSFWQI values indicated that the lake is in poor condition during all the three seasons indicating the deteriorated water quality.

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