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Evaluation of Seasonal Variation on Physico-Chemical Parameters and Assessment of Water Quality Index for Lonkheda Village (M.S.), India

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Abstract
Water is the basic need of human being. As the population on earth increases, rapid utilization of ground water as well as surface water takes place. Groundwater along with surface water is used for drinking as well as for other purposes; hence it is necessary to evaluate the quality of groundwater also. The impact of climate change majorly affects the quality of groundwater, but the impacts due to seasonal changes are not negligible. The noticeable changes can also be found by analyzing the quality of groundwater seasonally. The main objective of this study is to analyze the variation in physico-chemical characteristics of groundwater and on relative soil also according to various seasons and to focus on the drinking water quality index of Lonkheda village of district Nandurbar. The four samples of bore well water and soil of cultivating area of Lonkheda were tested for the general parameters along with physico-chemical parameters. The groundwater of the four samples of each season was analysed. Even though the Water Quality Index put the water into "poor water" category, none of the sample was found suitable. The amount of Phosphorus in winter season soil sample exceeds the desirable limit.

Keywords: Groundwater, Physico-chemical parameters, Seasonal impacts, Soil Quality, Water Quality Index

I. INTRODUCTION

All the living things in the world require water to grow and reproduce. Water quality performs important role in health of human, animals and plants [19]. Only 3% of the Earth's water is fresh water, slightly over two thirds of this is frozen in glaciers and polar ice caps. The remaining unfrozen fresh water is found mainly as Groundwater. Groundwater is one of the most valuable natural resource of the earth and is required for drinking, irrigation and industrialization. The resource can be optimally used and sustained only when quantity and quality of groundwater is assessed. According to WHO organization, about 80% of all the diseases in human beings are caused by water [5]. During the past few years groundwater along with surface water is used for drinking purpose, industrial and agricultural purposes, it is observed that the water is polluted and affecting the human health, soil nutrients, crop yield, livestock, biomass and environment. Human activities are a major factor determining the quality of the surface and ground water through atmospheric pollution, effluent discharges, use of agricultural chemicals, eroded soils and land use (Niemi et al.,) [25]. Anthropogenic activities and the change in climate conditions are the basic factors which affect the quality of groundwater. In case of soil of agricultural areas, an excessive use of fertilizers has directly or indirectly affected the groundwater quality [6]. Groundwater is the backbone of agriculture and drinking water security of India's rural and urban areas. The main objective of this study is to analyze the variation in physico-chemical characteristics of groundwater and on relative soil also. The quality of water resources depends on physico-chemical parameters. The study area chosen for finding the variation in physico- chemical parameters and WQI seasonally is Lonkheda. Lonkheda village is small village of Shahada Taluka in Nandurbar district. The population of Lonkheda village was 11004 as per the census 2011. The major source of income of the population is farming, so the quality assessment of soil and water play important roles. The irrigation water quality plays a vital role in deciding its management strategies for profitable farming. Nutrient depletion and soil degradation have gradually increased and have become serious threats to agricultural productivity in India. The problem of decline in soil fertility may reduce the maximum growth in productivity. Depending upon the cropping pattern, leaching, erosion, fertilizer used etc., and soil loses a considerable amount of nutrients and micronutrients every year. Human health is threatened by most of the agricultural development activities particularly in relation to excessive use of fertilizers.

The quality of soil depends upon the quality of water which filters through. The unplanned and non-scientific development of ground water resources, mostly driven by individual initiatives has led to an increasing stress on the available resources [2]. Water Quality Index (WQI) is one of the most effective tools to communicate information on the quality of water to citizens in a single number. The formulation and use of indices has been strongly advocated by agencies responsible for water supply and control of water pollution [5]. The present study highlights the WQI Model of ground water of Lonkheda village. The WQI model is prepared for the individually, which help in finding the variation in the quality of water seasonally. Further, the information obtained from the study will be useful for local people, environmental departments, public health departments etc. The main objectives of the study are Physical and chemical analysis of groundwater samples and application of Water Quality Index (WQI) model. Water quality index is created to give the Physico-Chemical Characteristics & Water Quality Index (WQI) of Lonkheda village. The samples of soil were also analyzed for various seasons namely rainy, winter and summer.

II. MATERIAL AND METHODS

The area for study for seasonal impacts on quality of groundwater and on the related soil is Lonkheda (Nandurbar). Lonkheda is a Village in Shahada Taluka in Nandurbar District of Maharashtra State, India. It belongs to Khandesh and Northern Maharashtra region. It belongs to Nashik Division. It is located at 3 KM from Shahada. The latitude of Lonkheda is 21.5675374 and longitude is 74.4870687. The main horticulture crops cultivated in the village are papaya, mango, banana etc. Rice, Jawar, Cotton and Pulses are the major crops of the district. From the rainfall data of previous years it was observed that the south west part of the district have 25% to 50% rainfall. The study area Lonkheda is facing the rainfall problem, which affects the productivity of crops.

Fig No. 1 Lonkheda Map

The samples of groundwater and soil were collected in three seasons, rainy, winter and summer. The four samples of bore well water and soil of cultivating area of Lonkheda were tested for the general parameters along with physico-chemical parameters. The representative sample of water that is taken should be the one that truly reflects the composition of water sample to be analyzed. Due to varying period of time that may lapse between sample collection and analysis, Storage condition must be such as to avoid undesirable loses, contamination for the above assessment, samples of both groundwater and soil are taken from the selected area of Lonkheda. Each water sample was collected in a one litre clean plastic container. The container was rinsed 2 or 3 times before collection of sample by the water which is to be collected. Soil samples was collected from 0-15 cm depth at each location and prepared for analysis according to the standard procedure. The total amount of mineral or organic soils are collected should provide at least 500 gm of sieved dry soil. The samples of soil were collected from four different locations of the village. The collected samples are brings to laboratory for analysis. The tests are done as per the standard methods prescribed in APHA. The soil samples were tested for pH, Electrical Conductivity, Organic Carbon, Nitrogen, Phosphorus, Zinc and Copper. The water samples were analyzed for following parameters:, pH, EC, TDS, TH, TSS, Cl, SO_4, COD, BOD, F, Zinc and Lead, using standard procedures of analysis recommended by APHA and compared with WHO and BIS. Water Quality Index (WQI) for groundwater quality of Lonkheda affects the quality of drinking water and the capacity of the surface water to support wildlife and healthy ecosystems. Water quality indices aimed for giving a single value to the water quality of a source. Anyone can then compare different samples for quality on the basis of the index value of each sample. For computing water quality index following are the three steps.

In the first step, each of the seven parameters has been assigned a weight (wi) according to its relative importance in the overall quality of water for drinking purposes as per BIS. The maximum weight of 5 has been assigned to the parameters Total Dissolved Solids and Fluoride due to its major importance in water quality assessment. In the second step, relative weight (Wi) is computed from the following equation:

$$Wi=wi/\sum wi \quad \text{---------- (1)}$$

$$Wi = wi\ 1i\ n\ \sum wi \quad \text{---------- (2)}$$

Where (Wi) is the relative weight, (wi) is the weight of each parameter and "n" is the number of parameters taken for water samples.

In the third step, a quality rating scale (Qi) for each parameter is assigned by dividing its concentration in each water sample by its respective standard according to the guidelines in the BIS and then result is multiplied by 100.

$$Qi = (Ci /Si) *100 \quad \text{---------- (3)}$$

Where, Qi is the quality rating for that parameter , Ci is the concentration of each chemical parameter in each water sample in mg/L, except pH, and Si is the BIS (Bureau of Indian standards) water standard for each chemical parameter in mg/l according to the guidelines of the BIS-10500-1991[1]. For computing the Water Quality Index (WQI), the Sub Index (SIi) is first determined for each chemical parameter, which is then used to determine the WQI as per the following equation:

SIi = Wi*Qi ----------(4)

∑ WQI = ∑Si----------(5)

SIi is the sub index of I th parameter, Qi is the rating based on concentration of i^{th} parameter and n is the number of parameter. The computed WQI values are classified into five types "excellent water", "good water", "poor water" "very poor water", "water unsuitable for drinking" as shown in Table 1.

TABLE I
WATER QUALITY CLASSIFICATION BASED ON WQI VALUE

WQI value	**Water quality**
<50	Excellent
50 – 100	good water
100-200	poor water
200-300	very poor water
>300	Water unsuitable for Drinking

III. RESULT AND DISCUSSION

The moderate range of pH for soil is 6.5 to 7.5. The soil with pH greater than 7.5 is called as sodic soil. All the seasonal samples of my study are sodic in nature. The increase in pH is due to high content of bi-carbonate and carbonates [3]. The electrical conductivity in the range of 0.195 to 0.375 mS/cm. Conductivity is nothing but a measure of total conductance of the ionized substances. Conductivity is affected by mobility of the ions, valences, actual and relative concentrations.

The organic carbon is in the range 0.72 percent to 1.10 percent, which depends upon the pH of humic substances. The amount of nitrogen varies between 155.45 kg/ha to 342.32 kg/ha, from rainy to winter season only. The amount of nitrogen is below the permissible standards in all seasons except winter season. The amount of phosphorus varies between 30.95 kg/ha to 58.60 kg/ha. The largest concentration of phosphorus is obtained in the winter season samples, which is slightly high than the permissible limit. The concentration of metals like zinc and copper is extremely high in each and every season sample. The physico chemical parameters of soil show variation in the quality according to the season. The excess Cu affects the plant growth, so it is necessary to prevent the soil of study area fro contamination of copper and zinc.

1) TABLE II.
CONCENTRATION OF PHYSICO-CHEMICAL PARAMETERS

Sr. No.	**Parameter**	**Rainy Season**	**Winter Season**	**Summer Season**
1	pH	8.28	8.43	8.01
2	Elect. Conductivity(mS/cm)	0.208	0.228	0.370
3	Organic Carbon (%)	1.10	0.74	0.88
4	Available Nitrogen(kg/ha)	160.87	342.32	190.67
5	Available Phosphorus(kg/ha)	31.94	57.80	44.91
6	Available Zinc(ppm)	3.96	1.14	4.22
7	Available Copper(ppm)	5.18	3.4	7.19

The pH values of the samples varied between 6.9 to 7.8 in rainy season, 7.27 to 7.37 in winter season and 7.72 to 7.86 in summer season. The pH levels of samples of every season were within the limits set by the WHO and BIS. The electrical conductivity of the samples varies from 0.89 to 1.38, which is within the limits of BIS. The permissible total dissolved salts for drinking water is 500 mg/L, whereas in the absence of potable water source the permissible limit is up to 2000 mg/L. It is found from the analysis; all the water samples of each and every season are within the maximum limit of 2000 mg/L. The range of TDS levels in the study area is 600 mg/L to 604.5 mg/L in rainy season samples, 565.05 mg/L to 572.0 mg/L in winter season and 818 mg/L to 820 mg/L in summer season. Major difference is there in the winter and summer season. After comparing these results it was found that temperature made difference in the quality of groundwater. High values of TDS concentration cause cancer, coronary heart disease and cardiovascular disease. These may affect persons who are suffering from kidney and heart diseases also water containing high solids may cause laxative or constipation effects. The total hardness ranged between 235.60 mg/L to 238.96 mg/L in rainy season samples, 198.00 mg/L to 199.92 mg/L in winter season and 237.00 mg/L to 239.12 mg/L in summer season. The total hardness is below the limit for each and every season. The concentration of TSS has a major difference of 0 mg/lit to 309 mg/lit. In summer season samples the concentration of TSS is zero whereas in rainy season it found maximum. Excess in concentration of hardness may cause Encrustation in water supply structure and adverse effect on domestic use. The chloride level ranged between 100.05 mg/L to 230.08 mg/L. The concentration of chloride is smaller in the samples of

rainy season whereas maximum in the summer season samples. Here it is observed that the chloride concentration in the samples fall well within the permissible limit (250 mg/lit-100 mg/lit). The level of sulphate varied between 36.00 mg/lit to 87.03 mg/lit from rainy to summer season. The sulphate concentrations are well within the permissible standards. The concentration of fluoride in drinking water is critical considering health problems related to teeth and bones. High fluoride concentration may causes dental fluorosis and skeletal fluorosis in human being, whereas the absence or low concentration fluoride concentration (< 0.5 mgL-1) cause tooth decay. The recommended desirable limit of fluoride is 1 mg/L [1]. In present study area, fluoride content in all samples of every season is well within the permissible standards. Biological Oxygen Demand (BOD) gives an idea of the quantity of biodegradable organic matter present in an aquatic system which is subjected to aerobic decomposition by microbes. Accordingly it provides a direct measurement of the state of pollution [1]. BOD is not available in the samples taken from the study area. The concentration of COD along with the metal zinc and lead is also found nil in the samples. Statistical analysis was done for samples of each season. The statistical analysis provides a mean value for accurate results. The WQI of all samples of each season taken were calculated according to the procedure explained above and are presented in Table 6, 7 and 8. The results obtained from this study revealed that WQI of groundwater of Lonkheda is "good water" for rainy and winter seasons. The computed WQI was 79.08 and 86.44 respectively. The WQI for the summer season is 107.48, which is "poor water" as per table 1.
The evaluation of water quality parameters of any area is very essential to know whether the water is suitable for drinking or not. If it is not suitable than treatments methods for purification of water should be apply before supply water for consumption. As the variation in the WQI according to the various seasons, the quality parameters along with WQI were affected by the temperature and various seasonal impacts.

TABLE III
NORMAL SERIES OF WATER QUALITY PARAMETERS OF GROUND WATER OF RAINY SEASON.

Sr. No.	Parameters	Minimum	Maximum	Mean	S.D	C.V
1	pH	7.50	7.80	7.65	0.13	0.02
2	EC	0.890	0.930	0.912	0.017	0.0002
3	TDS mg/lit	600.00	604.5	601.637	2.139	4.575
4	TH mg/lit	235.60	238.96	237.702	1.487	2.213
5	TSS mg/lit	300.0	309.0	305.75	4.031	16.25
6	Cl mg/lit	100.05	102.96	101.252	1.289	1.663
7	SO_4 mg/lit	36.00	39.02	38.242	1.495	2.235
8	F mg/lit	0.52	0.57	0.55	0.0216	0.0004

TABLE IV
NORMAL SERIES OF WATER QUALITY PARAMETERS OF GROUND WATER OF WINTER SEASON.

Sr. No.	Parameters	Minimum	Maximum	Mean	S.D	C.V
1	pH	7.27	7.37	7.32	0.045	0.002
2	EC	0.890	0.985	0.951	0.043	0.001
3	TDS mg/lit	565.0	572.0	568.01	3.545	12.567
4	TH mg/lit	198.00	199.92	198.99	0.784	0.616
5	TSS mg/lit	35	40	37.5	2.886	8.333
6	Cl mg/lit	133.35	135.99	134.96	1.146	1.315
7	SO_4 mg/lit	81.80	83.37	82.792	0.689	0.474
8	F mg/lit	0.80	0.84	0.815	0.0191	0.0003

TABLE V
NORMAL SERIES OF WATER QUALITY PARAMETERS OF GROUND WATER OF SUMMER SEASON.

Sr. No.	Parameters	Minimum	Maximum	Mean	S.D	C.V
1	pH	7.72	7.86	7.78	0.061	0.003
2	EC	1.250	1.381	1.29	0.061	0.003
3	TDSmg/lit	810	820	816	4.320	18.66
4	TH mg/lit	235.15	239.12	237.56	1.88	3.54
5	TSS mg/lit	0	0	0	0	0
6	Cl mg/lit	225.80	230.08	228.50	2.013	4.052
7	SO_4 mg/lit	85.00	87.03	86.25	0.948	0.90
8	F mg/lit	0.75	0.78	0.765	0.012	0.0001

TABLE VI
RELATIVE WEIGHT AND WATER QUALITY INDEX OF WATER QUALITY PARAMETERS FOR RAINY SEASON.

Sr. No.	Parameters	Indian Standard	Weightage (wi)	Relative Weight(Wi)	Quality rating (Qi)	Sub Index (Sli)
1	pH	6.5-8.5	3	0.115	117.69	13.57
2	EC	0.7-3.0	3	0.115	130.28	15.03
3	TDS mg/lit	500-2000	5	0.192	120.32	23.13
4	TH mg/lit	300-600	3	0.115	79.23	9.14
5	Cl mg/lit	250-1000	3	0.115	40.50	4.67
6	SO_4 mg/lit	200-400	4	0.153	19.12	2.94
7	F mg/lit	1-1.5	5	0.1923	55	10.57
			∑ wi = 26		WQI= ∑ Sli =79.08	

Table VII
RELATIVE WEIGHT AND WATER QUALITY INDEX OF WATER QUALITY PARAMETERS FOR WINTER SEASON.

Sr. No.	Parameters	Indian Standard	Weightage (wi)	Relative Weight(Wi)	Quality rating (Qi)	Sub Index (Sli)
1	pH	6.5-8.5	3	0.115	112.61	12.99
2	EC	0.7-3.0	3	0.115	135.85	15.67
3	TDS mg/lit	500-2000	5	0.192	113.60	21.84
4	TH mg/lit	300-600	3	0.115	66.33	7.653
5	Cl mg/lit	250-1000	3	0.115	53.98	6.22
6	SO_4 mg/lit	200-400	4	0.153	41.39	6.36
7	F mg/lit	1-1.5	5	0.1923	81.5	15.67
			∑ wi = 26		WQI=∑ Sli =86.44	

Table VII
RELATIVE WEIGHT AND WATER QUALITY INDEX OF WATER QUALITY PARAMETERS FOR SUMMER SEASON.

Sr. No.	Parameters	Indian Standard	Weightage (wi)	Relative Weight(Wi)	Quality rating (Qi)	Sub Index (Sli)
1	pH	6.5-8.5	3	0.115	119.69	13.81
2	EC	0.7-3.0	3	0.115	184.28	21.26
3	TDS mg/lit	500-2000	5	0.192	163.2	31.38
4	TH mg/lit	300-600	3	0.115	79.18	9.14
5	Cl mg/lit	250-1000	3	0.115	91.4	10.55
6	SO_4 mg/lit	200-400	4	0.153	43.13	6.63
7	F mg/lit	1-1.5	5	0.1923	76.5	14.71
			∑ wi = 26		WQI=∑ Sli =107.48	

IV. CONCLUSIONS

The study of evaluation of soil parameters variation revealed that the soils from study area are alkaline nature. The preventive measures should be adopted for reducing the concentration of zinc and copper in the study area. After the careful study of analysis, interpretation and discussions of the numerical data it is revealed that water is soft in all the samples of each season. The concentration of fluoride is well within the permissible limit. The concentration of Total dissolved solids in all samples of each season is well within the permissible limit. The Water Quality Index (WQI) falls in the Good range for the rainy and winter season, while fall poor water for the summer season samples. Dissolved solids are in all samples of each season is well within the permissible limit. The Water Quality Index (WQI) falls in the Good range for the rainy and winter season, while fall poor water for the summer season samples. Application of water quality index (WQI) in this study has been found useful in assessing the overall quality of water seasonally. This method appears

to be more systematic and gives comparative evaluation of the water quality of each sample. The sulphate and chloride concentrations of all three samples are well within the permissible standards. The analysis reveals the quality of groundwater the study area needs some treatment before consumption.

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