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Impact of sugar industries of kushinagar district (U.P.) on water quality: Using remote sensing and Geographical information System (GIS)

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Abstract

Quality of water is an important aspect for drinking and other related requirement. Water has been the most exploited natural resource due to ever increasing demand of man for food, cloth, industrialization. In the present study effect of sugar effluent on water quality at given region in two seasonal conditions i.e. pre rainy season and post rainy season and the sampled data was analyzed separately for pH, Total dissolved solid (TDS), Nitrate, Phosphate, Dissolved oxygen (DO), Biochemical oxygen demand (BOD) and Chemical oxygen Demand (COD) and followed by G.I.S. to develop respective maps. It was found that the pH value was alkaline in pre rainy season and slightly acidic in post rainy season. TDS was found high in 66% area during pre rainy season and 74.6% in post rainy season above permissible limit . In pre rainy season 83.4% area and in post rainy season 98.4% area contains high electrical conductivity .In pre rainy season BOD was found more than 6mg/l in 80.9% in pre rainy season and in 84.2% area in post rainy season. COD was found above prescribed limit (>10mg/l) in 59.5%area in pre rainy season and in 93.6% area in post rainy season 33.3% area contain high phosphate in pre rainy season 46.03% area contains high phosphate in post rainy season .Nitrate was found in permissible limit in pre rainy season 46.6% area was found to contain nitrate in post rainy season 7.1% of the geographical area is having fluoride concentration more than 1.5mg/l and 28.5% area is having fluoride concentration below the normal limit .Thus 35.6% of total area is not suitable for drinking purpose.6.34% area contain fluoride above prescribed limit

Key words: - *Dissolved oxygen, BOD, COD, GIS.*

Introduction

Ground water is important source of fresh water for agriculture, drinking domestic uses in many regions of the world and also in India. Demand of ground water has been increasing day by day for irrigation by bringing area under cultivation. Water generally contains different species of cations and anions in varying amounts. The concentration of dissolved constituents in water is an important determinant for its quality. (Islam *et al*., 2003). Rapid growth of population, urbanization, coupled with industrialization pose serious concern to the vulnerability of water resources owing to regional imbalance of chemical parameters and eventual safe use of ground water for drinking purpose (Mathur and Priyakant, 2005).

In general most of sugar industries don't process the effluent for removal of organic and inorganic pollutants and release the entire effluent outside the premises which eventually spreads throughout the low lying area adjacent to the sugar factory or discharges into natural course. This in turn can migrate and mix with the shallow water aquifer system through seepage and therefore can cause detrimental effect on ground water quality. Total estimated amount of production of sugar industries in India is 7.5×10^6 tonnes/ year. Sugar mill consume 1500-2000 liters of water and generate about 1000 liters of waste water ton of crane crushed.The effluent is mainly floor washing waste water and condensate water, leakage in valves

and glands of pipeline add sugarcane juice syrup, molasses in the effluent. The sugarcane effluent has BOD 1000 -1500mg/l, but appears relatively clean initially, however after stagnating for some time it turns black and starts emitting foul odour if untreated effluent is discharged in water courses it also depletes dissolved oxygen in water and make environment unfit for aquatic life. If untreated effluent is discharged on land decaying organic solids ,oil and grease clog the soil pores .

The district Kushinagar lies between latitudes $26^0$50' and 27^0 0' N and longitude 83^0 40' and 84^0 0' E and fall in the survey of India toposheet No. 63N/9 and 63 N/13. Topographically the area exhibits a flat terrain with a gentle slope from north to south. It is situated in the doab of river (Gandak, Rapti and Ghagra). It comprises three tehsils of viz., Padrauna, Ramkola and Kaptanganj. The main surface water source is Banari nala, which traverses the entire area in a zigzag way flowing in North West direction. Western Gandak network canal is the main irrigation canal system. The other canals of the area include Kurmai minor, Barhara distributory, Padrauna minor, Khasai Branch and Sepaha distributory. A Number of lakes namely Kamaini tal, and Balkariyal tal are also located in the area, Climate of this area is moderate as compared to western part of state. The temperature is maximum in May and June seldom exceed 41^0C and generally it remains around 36^0C during winter, the average minimum temperature for December and January drops to about 10^0C. Average annual rainfall in the area is about 1145 mm. Bulk of the rainfall occurs during June to September due to South-West monsoon. The area under reference is a fertile alluvial plain with gentle slopes towards South-East. Major amount of sugar industries located in area of Padrauna and Ramkola Tehsils.

Material and Methods

Water samples were collected from 3 areas Kaptanganj, Ramkola, Padrauna in prerainy season (April to May) and in post rainy season (Oct. to Nov.). Samples were collected from different point and non point sources i.e. River, tube wells, canals, hand pumps etc. From each sampling site two samples were collected in chemical resistant pre cleaned plastic bottles, which were thoroughly washed twice with the some water required to be analyzed. The concentration of total dissolved solids was measured on the spot itself with the help of portable electric conductivity meter. TDS was determined by gravimetric technique . Dissolved Oxygen and Biological Oxygen Demand and COD were measured by winkler's-Iodometric method, 5-days BOD test, closed reflux colorimetric method respectively. Fluoride, Nitrate, Phosphate measured by UV-Vis. spectrophotometric method (APHA, 1992; Abbasi, 1998).

Result and Discussion

The monitoring parameters were measured on the basis of pre-rainy season and post rainy season effect on ground water and surface water. quality. The average analytical result of 42 water samples in pre-rainy season and 63 water samples in post rainy season, collected from hand pumps, river, tube wells, canals, drains etc are shown in table 1. All the eight parameters i.e. pH, TDS, Nitrate, phosphate,D.O., B.O. D.,C.O. D., fluoride in ground and surface water were compared with the permissible/tolerable limit laid dawn by B.I.S. (1991).

A pH range of 6.5-8.5 is normally acceptable as per guide line suggested by BIS (1991) and WHO (1993) pH values at Kaptanganj , Padrauna and Ramkola varies from 6.83-10.27 , 7.2-8.12 and 7.14-8.71 indicating alkaline nature of water at all stations. The pH range observed at, Padrauna and Ramkola were well among prescribed range and at kaptanganj were on alkaline side But in post rainy season the pH value of these stations Kaptanganj, Padrauna and Ramkola ranges from 7.24-8.51,6.8-8.2 and 4.4-8.5.

The electrical conductivity limit is300 µS /cm, normally acceptable as per guide line suggested by BIS (1991) and WHO (1993) .The conductivity value at Kaptanganj , Padrauna and Ramkola ranges from 189-1324.8, 484-1901and 690-1885 µS /cm respectively in pre rainy season. High conductivity values are observed in low flow periods at the above three stations. It is due to industrial waste disposal at water bodies and dissolved solids from water shed Figure 1shows spatial and percentage distribution of electrical conductivity in district. It clearly shows 83.4% of electrical conductivity in excess of prescribed limit only 16.6% suitable with electrical conductivity for drinking purpose. Electrical conductivity at Kushinagar district increases during post rainy season .High conductivity was observed in high flow periods at above three stations. The conductivity value at Kaptanganj, Padrauna and Ramkola ranges from 155-1480,600-2030 and 541-2000 µS /cm respectively (Table 1).

GIS analysis (Fig.1) revealed that 1.6% area of district Kushinagar contains less than 300 µS /c.m and safe for drinking purpose. Total dissolved solids (TDS) indicate general water quality or salinity and is usually related to conductivity. Water containing more than 500mg/dl of TDS is considered suitable for drinking .500mg/dl is the desirable limit and 2000mg/dl is the permissible limit (BIS,1991; WHO, 1993).The TDS Kaptanganj, Padrauna and Ramkola vary from 122-8611mg/dl, 305-1157mg/dl and 414 - 6329mg/dl respectively .High TDS at these three stations is due to industrial waste percolation or seepage in ground water .The G.I.S. analysis reveal that 66.6% area of district kushinagar contains TDS>500mg/dl and is not safe for drinking purpose (Fig 4).TDS in post rainy season in Kaptanganj , Padrauna and Ramkola vary from 88.35 - 837.9, 342 - 6441and 308..37 – 1140 (Table 1).

On the basis of spatial and percentage distribution of TDS in Kushinagarin post rainy season 74.60% area of Kushinagar contains TDS > 500 mg/L and is not safe for drinking purpose [Fig-2]. In pre-rainy season 83.40% area and in postrainy season 98.40% area of Kushinagar contains E. conductivity > 300 µS/c.m. Higher values of TDS at Kushinagar appear due to the contribution of dissolved solid from watershed and disposable of Industrial effluent on water bodies; one of the most important reasons are high amount of agricultural runoff and discharge of effluent on water bodies (Mathur, 2005). Contribution of watershed due to dissolution or weathering of rocks and soil as water passes over or percolates through them (Decoursey, 1985). A large amount of sediment load is transported from the watershed during the steep slopes of the land (Rai and Sharma , 1998).

Dissolved Oxygen (DO) is important parameter in the drinking water and is inversely related to the Biological oxygen demand (BOD) and chemical oxygen demand (COD). DO, BOD and COD values at Kaptanjanj range from 5.2 - 7.8mg/l, 2-55.0mg/l and 7.2 - 82.0 respectively. At Padrauna values of DO, BOD and COD range from 5.3 -8.2mg/l, 4.0-34.0mg/l and 5.8 -66.5 and at Ramkola values of DO, BOD and COD 4.9 - 6.3mg/l, 2.8 - 20.8mg/l and 5.2-24.6mg/l.These values are much higher than the permissible limit prescribed by WHO (1993) and BIS (1991) , D.O 4.0-6.0mg/l BOD<6mg/l and COD<10mg/l .At Kaptanganj these values are much higher than Ramkola and Padarauna due to positive loading of industrial waste at water bodies In the post rainy season values of DO, BOD and COD 5.4 - 7.6mg/l, 4.2-10.4mg/l and 8.42 - 22.42mg/l. In Padaurana values of DO, BOD and COD was 0.0-6.4 mg/l, 8.2-88 mg/l and 19.2-52.2 mg/l at Ramkola 5.1-7.0mg/l, 3.0-14.6mg/l & 7.42 - 28.9mg/l (Table 1). The condition in post rainy season of water quality at Kuhinnagar shows strong positive loading of BOD and COD and strong negative loading on pH and DO. This represent anthropogenic pollution sources and can be explained on the basis that high level of dissolved organic matter consume large amt of oxygen, which undergoes anaerobic fermentation processes leading to formation of ammonia and organic acids. Hydrolysis of this acidic material causes decrease of water pH values (Singh *et al*., 2004).

In the pre rainy season nitrate value at in Kaptanganj , Padrauna and Ramkola ranges from 0.09-3.95mg/l, 0.09-8.78mg/l and 0.29-1.4mg/l respectively .None of the samples contain nitrate beyond the permissible limit of 40.0mg/l as prescribed by BIS (1991) for drinking purposes. Concentration of nitrate in post rainy season at Kaptanganj, Padrauna and Ramkola 4.8-48mg/l, 11.09-84.79mg/l and 3.38-72.96mg/l respectively (Table 1).

Nitrate concentration in ground water is enhanced by shallow ground water table and excessive application of nitrogenous fertilizer (Steversen, 1996). In an around area of high urbanization, industrialization, municipal, industrial water may contribute high level of nitrate to ground water (Handa *et al.,* 1982). Nitrate concentration showed a clear seasonal pattern .The seasonable difference can be account for the variation in the amt of readily leachable nitrate within soil profile (Powlson , 1993). Autumn sown crops utilize only small amount of nitrate the large quantity being available for leaching. During summer month (pre rainy season) plant uptake is high available nitrate is low on the basis of percentage distribution of ground water in Kushinagar 47.6%of ground water contain nitrate above 45mg/l and is not safe for drinking.

The phosphate concentration at Kaptanganj, Padrauna and Ramkola ranges from 0.01- 0.63mg/l, 0.01-2.85mg/l and 0.01-2.85mg/dl respectively high as compared to 0.1mg/l limit .On the basis of percentage distribution of water quality 33.3% of area has poor water quality and 66.6% area has good quality. Phosphate concentration was high in post rainy season The phosphate concentration at Kaptanganj , Padrauna and Ramkola ranges from 0.09-0.98mg/l,0.02-0.91mg/l and 0.0-0.045mg/l respectively. On the basis of percentage distribution of ground water in Kushinagar 46.03% area contains phosphate above0.1mg/l and is not safe for drinking purpose and remaining 53.97% area contains phosphate above permissible limit. The high amount of phosphate in ground water in post rainy season due to increased weathering and break down of the soil structure and addition of mineral fertilizers (Jenkins, 1995).

On the basis of spatial and percentage distribution of ground water in Kushinagar district 6.4% area contain fluoride >1.5mg/l and is not safe for drinking purpose. Fluoride has considerable physiological significance for man and animal. Evidences so far accumulated shows that the upward adjustment of fluoride in drinking water to 1.0 mg/l result in a great reduction in the incidence of dental carries (Handa, 1975). As such the problem of high level of fluoride is encountered in many geographical zones of globe. The globe prevalence of fluorisis is reported to be about 32% (Srivastava, 1997). It is not surprising that 17 of the states and union territories are endemic for fluorosis (Ministry of Health, 1962 and Srinivansan, 1959).

Conclusion

The main objective of this study was to undertake drinking water quality survey of India in sugar industrial area of district Kushinagar. Eight parameters viz. pH, Electric Conductivity, TDS, DO, BOD, COD, Fluoride, Nitrate & Phosphate in ground water analyzed separately and further combined to delineate, suitable moderate and poor quality zones in the entire district. Areas having high concentrate of these parameters were highlighted and classify the nature of problem using chemical & GIS based techniques Release of entire effluent outside the premises which eventually spreads throughout the low lying areas adjacent to the sugar factory or discharges into natural water course. This in turn can migrate and mix with the shallow water aquifer system through seepage and therefore can cause detrimental effects on the ground water quality.

It may be inferred from the study that the areas, which contains the high Total Dissolved Solid values water, should be recharged with the rain water using the percolation wells. Since the untreated water is being used, the consumer will have the health effect due to high degree of residue. High concentration of

fluoride content in the study area need urgent attention to present possible health hazards by way of getting defluoridation plant and to inhibit discharge of sugar industry waste on water bodies. Other remedial measures like use of lime, alum, bone charcoal filters may be used on domestic scale (Valdiya, 1987).

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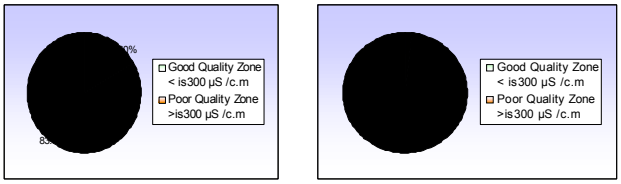
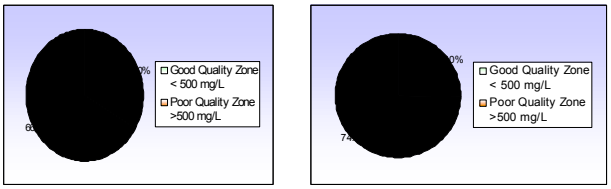
Table1. Comparitive data of various parameters in Kushinagar District during pre rainy and post rainy season.

Season	Site	Parameters								
		T.D.S (mg/l)	pH	E.C. (µS/cm)	D.O (mg/l)	B.O.D (mg/l)	C.O.D (mg/l)	NO_3^- (mg/l)	PO_4^{3-} (mg/l)	Fl (mg/l)
Pre rainy	Kaptanganj	122-8611	6.83-10.27	189-1324.8	5.2-7.8	2.0-55.0	7.2-82.0	0.09-3.95	0.01-0.63	0.35-1.50
	Padrauna	305-1157	7.2-8.12	484-1901	5.3-8.2	4.0-34.0	5.8-66.5	0.09-8.78	0.01-2.85	0.17-0.96
	Ramkola	414-6329	7.14-8.71	690-1885	4.9-6.3	2.8-20.8	5.2-24.6	0.29-1.4	0.01-0.66	0.34-1.56
Post rainy	Kaptanganj	88.35-8379	7.24-8.51	155-1480	5.4-7.6	4.2-10.4	8.42-22.4	4.8-48	0.0-0.98	0.37-1.78
	Padrauna	342-6441	6.8-8.2	600-2030	0.0-6.4	8.2-88	19.42-52.2	11.09-4.79	0.02-0.91	0.41-1.03
	Ramkola	308.37-140	4.4-8.5	541-2000	5.1-7.0	3.0-14.6	7.42-28.9	3.38-72.96	0.0-0.045	0.30-1.57



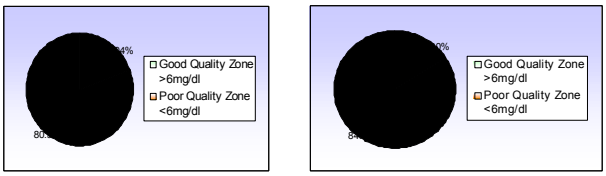
Pre rainy **Post rainy**

Fig1. Percentage distribution of electrical conductivity in Kushinagar district



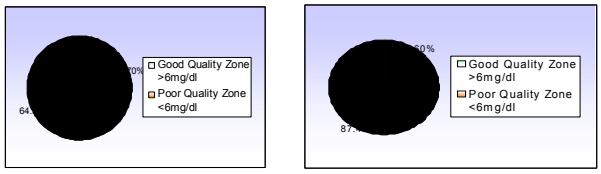
Pre rainy **Post rainy**

Fig. 2. Percentage Distribution of TDS inground water in District Kushinagar



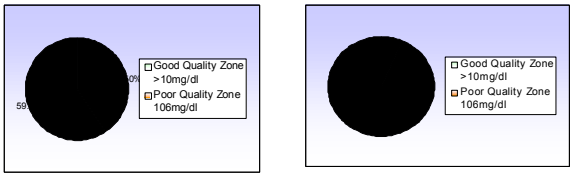
Pre rainy **Post rainy**

Fig 3 Percentage Distribution of DO in ground water in District Kushinagar.



Pre rainy **Post rainy**

Fig. 4. Percentage Distribution of BOD in ground water in District Kushinagar.



Pre rainy **Post rainy**

Fig. 5. Percentage Distribution of COD in ground water in District Kushinagar.

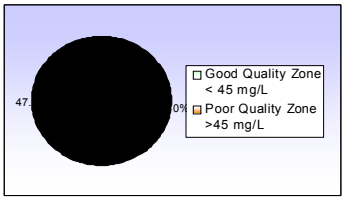
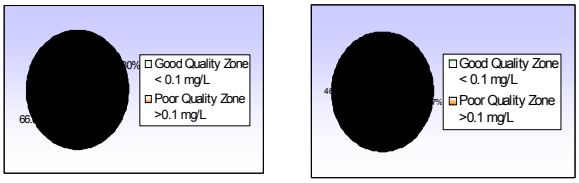
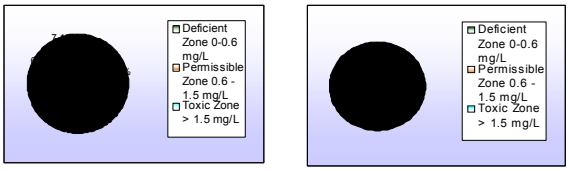


Fig. 6. Percentage Distribution of Nitrate in ground water on Post-rainy season, District Kushinagar



Pre rainy **Post rainy**

Fig. 7. Percentage Distribution of Phosphate in ground water District Kushinagar.



Pre rainy **Post rainy**

Fig. 8. Percentage Distribution of Fluoride in ground water on , District Kushinagar.