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Assessment of Surface Water Quality in Jaunpur District, for Drinking Water and Irrigation Suitability

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ABSTRACT

Surface water is the major source for drinking as well as irrigation in Jaunpur district of Uttar Pradesh. Manifold in last decades which leads to increase in population, urbanization, land use change and development activities that had over exploit and polluted the water resource of this region. In this contest on attempt has been made to assess the quality of surface water in Jaunpur District. To the suitability of water which is use for drinking or irrigation purposes. The results obtained from chemical analysis were compares with the standard of WHO. Study should that the parameter such as TDS, pH, alkalinity, Total hardness, DO, Ca^{++} and Mg^{++} were found to be within the permissible limits of WHO guidelines, whereas EC,TDS etc. are above desirable limits. Therefore water may be use for irrigation purpose and after purification also useable for drinking purpose.

Keyword: Surface water Quality, Irrigation, and Drinking Water.

1. INTRODUCTION

Water constitutes 65-95% of the body weight of an organism. Precipitation of water vapours in the form of rain, snow dew, hail etc. is the chief source of water in the environment. The ocean cover about 70% of the earth's surface, contain 97 percent of all the water on the earth. Only about 3 percent of the water on earth is freshwater and most of it is not easily available to people. It includes water locked in glaciers and caps, more than 2 percent of earth water. About half of 1 percent of the earth's water is beneath the earth surface. River and lakes contain only about one fifth of 1 percent of the earth's water. The fresh water amount on earth is 37 million Km^3; the ultimate source of fresh water is rainfall. Cities and villages can draw fresh water from only two sources: (I) rivers and lakes (II) the ground water. The problem of water quality deterioration is mainly due to human activities such as disposal of dead bodies, discharge of industrial and sewage wastes and agricultural runoff which are major cause of ecological damage and pose serious health hazards (Meitei *et al*.,)[5]. The degree of

pollution is generally assessed by studying physical and chemical characteristics of the water bodies (Duran and Suicnz)[2]. The availability of good quality water is an indispensable feature for preventing diseases and improving quality of life. Faecal pollution of drinking water causes water – borne disease which has led to the death of millions of people both in cities and villages.

In agriculture, water quality is related to its effects on soils, crops and management necessary to compensate Problems linked to water quality. It is very important to note that not all problems of soil degradation like salinity, soil permeability, toxicity etc. can be related to irrigation water quality.

The present investigation was carried out some important objectives.

- To study the physico-chemical characteristics of surface water of jaunpur district.
- To study the sapital variation in concentration of major cations (Ca, Mg, Na and K) anions (F, Cl, NO_3, SO_4, HCO_3) and other water quality parameters.
- To assess the quality of surface water of Jaunpur district for its suitability for drinking and irrigation uses.

2. STUDY AREA

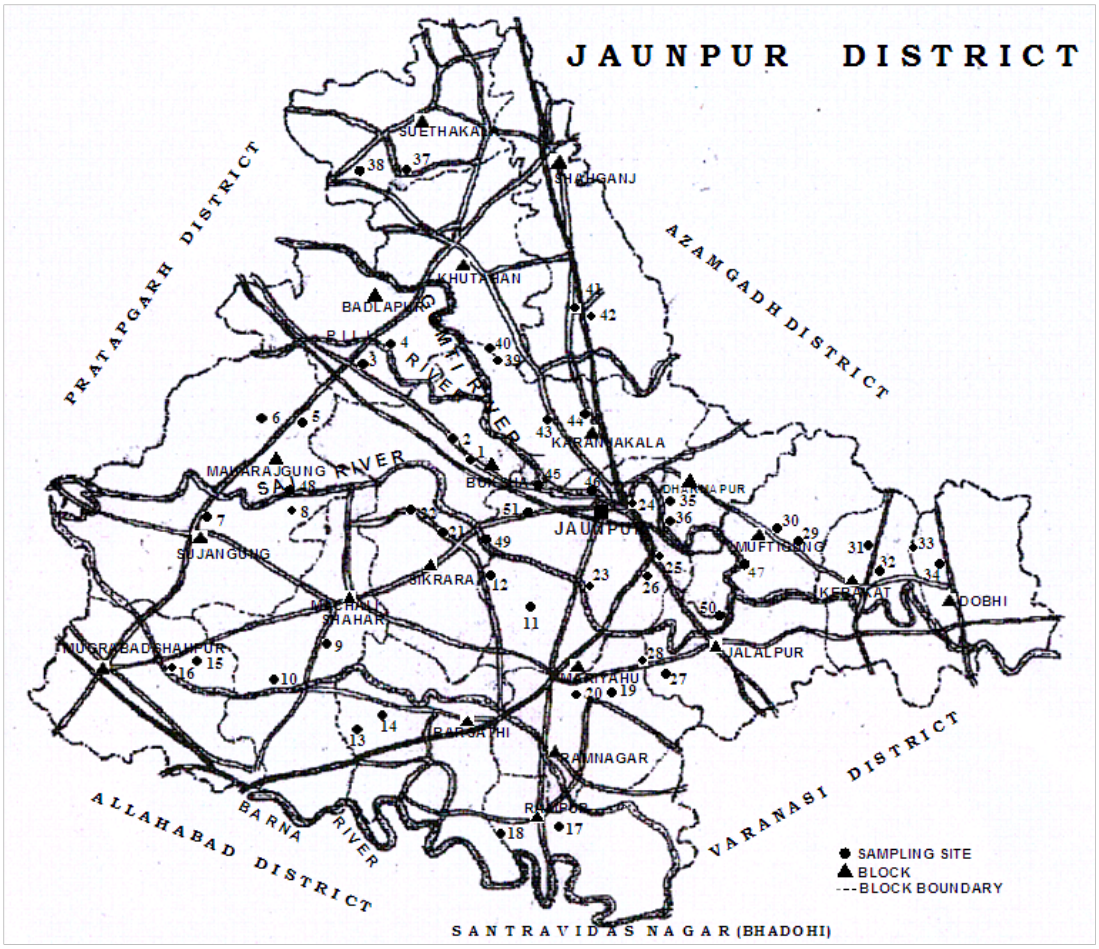
Jaunpur is one of the important districts of eastern part of Uttar Pradesh, India. It lies between 25^0 24' N and 26^0 12' N latitude and 81^0 19' E and 82^0 27' E longitude. According to the 2001 census, district had a population of 4586181 with the urban population of 299936 and 4285786 ruler populations. The climate of district is extreme nature with the temperature soaring to 48-45 ^{0}C in the summer and dipping to 5-7 ^{0}C in the winter. Average rainfall received by the district is 987 mm. Majority of the district population depend upon agriculture for their livelihood.

Gomti and Sai River, Sharda canal and pond etc. are the major source of water in Jaunpur district. After treatment, the surface water is supplied to various areas through pipelines for municipal and other uses. So surface water is very much valuable resource for this region. Both the quality and quantity of this resource should be maintained for better future of the local people.

3. ANALYTICAL METHODS

Approximately 2-litters of water sample from each station have been collected in sampling bottles and bring to laboratory for analysis. It is important that the sample must represent the water source and special care may be needed to ensure that. Method of sampling varies depending on different sources such as (1) rivers, (2) non flowing ponds and (3) canal water sources. Samples from rivers must be taken from the fastest flowing part, the mid-way along the width of the river.

The samples from lakes or ponds should come from the canter and the deepest part of the lake and sample from canal taken from upstream and downstream. Samples are collected in 1 to 2 litre glasses or PVC bottles. Samples brought to the laboratories should be analyzed without delay to prevent biological transformation.



Figare-1. Map of Jaunpur District showing the different sampling site

4. ANALYSIS

Methods of analysis regarding water quality are mainly of titrimetry, turbidimetry, and electrical conductivity and of flame photometry. Additionally, pH measurements are routinely included, indicating whether acidity or alkalinity may be of a problem. Electrical conductivity measurements are made very easily and routinely to assess total salt concentration of water samples. Empirical relations exist, relating electrical conductivity measurements with other concentration units such as ($\mu s/cm^{-1}$). Sulfate anion (SO_4) is usually analyzed with turbid metric method. The simplest method of analysis for sodium and potassium are to use flame photometer, although some laboratories may prefer using atomic absorption spectrometer if available.

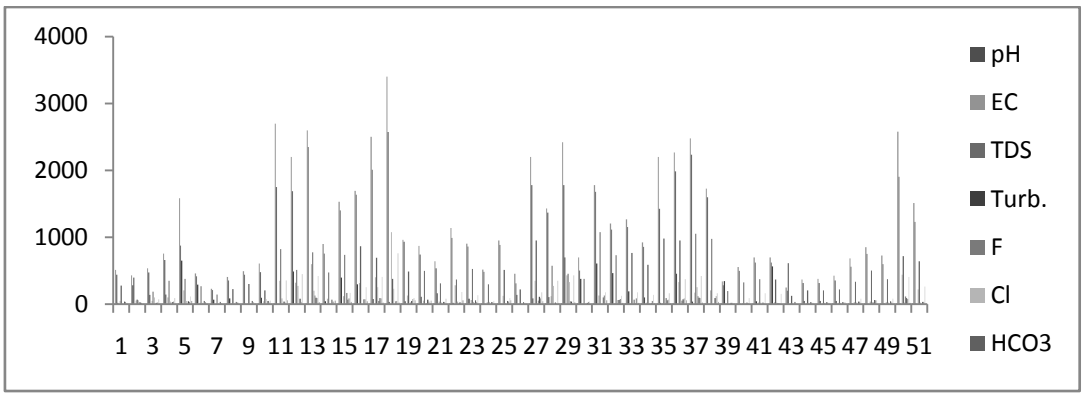
5. RESULTS AND DISCUSSION

The physico-chemical characteristics provide a fair idea of the water quality in any water body. The results of the physicochemical characteristics of Jaunpur district water are summarized in Fig-2. Ellis[3] has observed that a pH range of 6.7 to 8.4 is suitable for the growth of aquatic biota. The water in Jaunpur district was always alkaline throughout the period of study. Alkaline pH was also observed by Shaikh and Yeragi[8] in river Tansa during whole study period, while Varma[11] have observed acidic nature of water of Subarnarekha river due to discharge of copper industrial effluents in this river. The minimum pH value 6.6 was recorded at Station-jsw-2 and maximum pH 8.8 was recorded at Station-jsw-40.

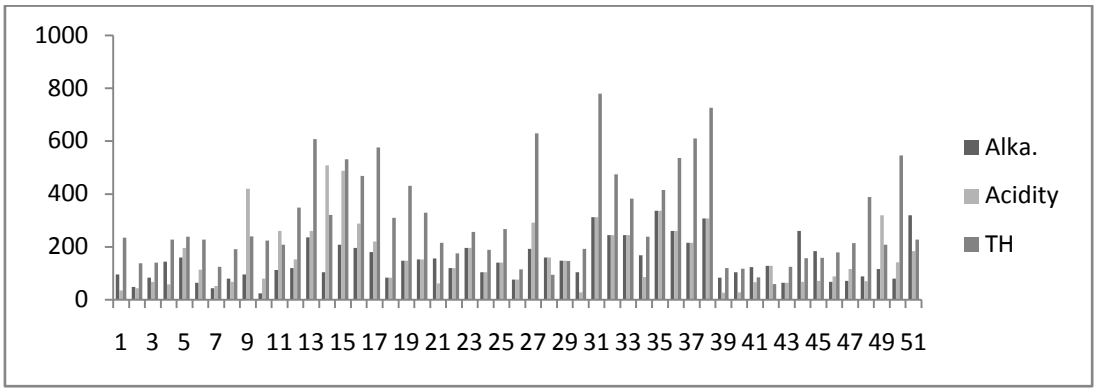
Conductivity is the measure of capacity of a substance or solution to conduct electrical current through the water. In the present study, lowest conductivity value (231 µs/cm^{-1}) was observed at Station-jsw-7 and highest value of conductivity (3400 µs/cm^{-1}) was observed at Station-jsw-18.

Total dissolved solids are composed of carbonates, bicarbonates, chlorides, sulphates, phosphates and nitrates of Ca, Mg, Na, K, and Mn and organic matter, salts and others particles (Mishra and Saksena,)[6]. Minimum total dissolved solids (203 mg/l) were recorded at Station-jsw-43, while maximum value (2351 mg/l) was recorded at Station-jsw-13.

Transparency or light penetration depends on the intensity of sunlight, suspended soil particles, turbid water received from catchment area and density of plankton etc. (Mishra and Saksena,[6]; Singh,;[10] Kulshrestha and Sharma,)[4]. Transparency of river water is also affected due to total solids partly or fully decomposed organic matters, silts and turbulence caused by the currents, waves, human and cattle activities (Singh *et al.*,)[9]. Seasonal impact was also seen on water transparency indicating higher values during winter and summer seasons, where as lower values are evident in monsoon season. The transparency values were less in monsoon season due to high current which erodes the bank of the river and due to turbid flood water, suspended matter and dissolved particles. High value of transparency was recorded in late post monsoon and winter months as has also been observed by Singh *et al*.,[9] Nath and Srivastava[7] and Shaikh and Yeragi[8]. Flow rate of water bodies generally depends upon the amount of water available and on its depth. The colour of river water was very much turbid in monsoon season and except for monsoon season; the colour of water was transparent. The minimum turbidity (2.4 NTU) was recorded at Station-jsw-13 and maximum turbidity (654.0 NTU) was recorded at Station-jsw-5.



Unit: mg/l except EC (µs /cm-^{1}) pH, and Turbidity (NTU)



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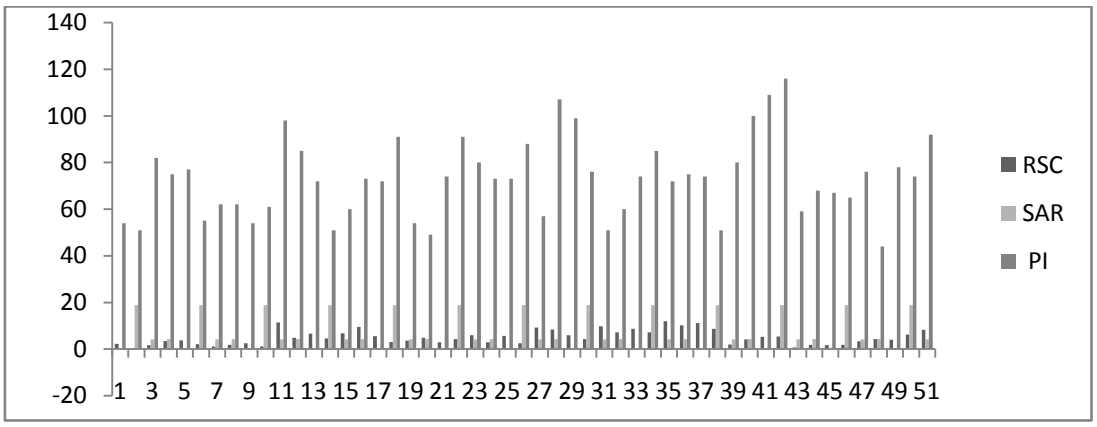

Unite- RSC, SAR (meq/l)

Figure – 2: The Variation of Water Quality of Surface Water of Jaunpur District.

The Fluoride at station-jsw-51, minimum value was recorded (0.27 mg/l) and maximum Fluoride (4.81mg/l) was recorded at Station-jsw-35.

The concentration of chloride was comparatively lower for being very low available. Chloride is found widely distributed in nature in the form of salt of sodium, potassium and calcium. natural fresh water high concentration of chlorides is regarded as an indicator of sewer pollution. Minimum chlorides (3 mg/l) were recorded at Station-jsw-7, while maximum value (1080 mg/l) was recorded at Station-jsw-18.

Nitrate is the most highly oxidized and usually the most abundant form of combined inorganic nitrogen in surface water minimum Nitrate (0.2 mg/l) were recorded at Station-jsw-4 and 51 and maximum value (167 mg/l) was recorded at Station-jsw-15.

The concentration of sulphate in surface water, minimum value (0.6 mg/l) was recorded at Station-jsw-20 and maximum sulphate (275 mg/l) was recorded at Station-jsw-12.The concentration of bicarbonate in surface water, minimum value (65 mg/l) was recorded at Station-jsw-2 and maximum bicarbonate (1075 mg/l) was recorded at Station-jsw-31.

Calcium and Magnesium in surface water varies from 8 to 108.5 mg/l and 7.6 to 129.3 during the period of study. Sodium is one of the important cation occurring naturally. Sodium concentration in irrigation water and soil is of great interest as high sodium contents makes soil hard to plough and unsuitable for seedling emergence. Surface water had sodium concentration from 1.1 mg/l at Station-jsw-7 and 761 mg/l at Station-jsw-18 and potassium level from 2.3 mg/l at Station-jsw-43 to 57.9 mg/l at Station-jsw-36 in the month of December, suggesting their moderate but harmless concentration. When various parameters of our study are compared with that of Indian standards (IS, 1974, 1991) for public water supply, fish culture and irrigation, it was revealed that all such parameters are well within the limits.

6. SUITABILITY FOR DRINKING AND DOMESTIC USES

To assess the suitability for drinking and public health purposes, the hydrochemical parameters of the surface and subsurface water of the study area are compared with the prescribed specifications of WHO (1997) and Indian standard for drinking water i.e. IS-10500**.** Most of the surface water of the study area found suitable for drinking and domestic uses with few exceptions, as most of the parameters are within the permissible limits.

The total hardness (TH) of the analyzed surface water samples of Jaunpur district varies between 59 to 780 mg /l (Avg. 297 mg /l) indicating soft to very hard types of water. The data indicate that only one surface water sample has TH values higher than 600 mg/l, which is the potable limit (BIS 1991) the high TH may cause the encrustation on water supply distribution systems.

The values of TDS and EC exceed the permissible limit in 11 and 17 surface water samples, indicating the higher ionic concentration. Concentration of sulphate and nitrate at some sites in surface water are also exceeding the Indian permissible limits (400

mg /l and 45 mg /l) restricting its direct uses for drinking purposes. Waters with about 200-400 mg/l sulphate have a bitter taste and those with 1000 mg/l or more of SO_4 may cause intestinal disorder.

7. SUITABILITY FOR IRRIGATION USES

The parameters like total hardness (TH), sodium percentage (Na%) residual sodium carbonate (RSC), total dissolved solids (TDS), sodium adsorption ratio (SAR), permeability index (PI) and magnesium hazard (MH), which affects the quality for irrigation purposes were also computed and results are furnished in Figure – 3. The important hydrochemical properties of surface water to determine its suitability for irrigation are.

(a) Alkali and Salinity Hazard

Electrical conductivity (EC) and sodium concentration are very important in classifying irrigation water. The total concentration of soluble salts in irrigation water can thus be expressed for the purpose of classification of irrigation water as low (EC = <250 µS cm^{-1}), medium (250-750 µS cm^{-1}), high (750-2250 µS cm^{-1}) and very high (2250-5000 µS cm^{-1}) salinity classes. While a high salt concentration (high EC) in water leads to formation of saline soil, a high sodium concentration leads to development of an alkaline soil.

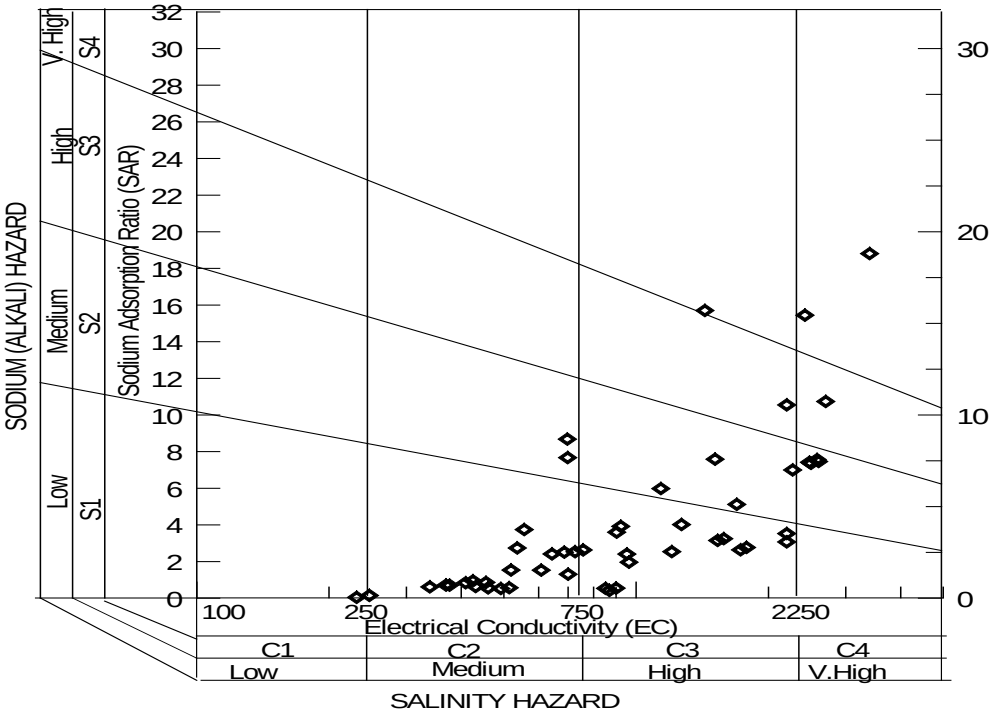

Figure – 3: Surface water classification according to EC and SAR values for irrigation purposes.

The calculated value of SAR in the study area ranges from 0.04-18.81 in surface water. The plot of data on the US salinity diagram, in which the EC is taken as salinity hazard and SAR as alkalinity hazard, shows that most of the water samples fall in the category C3S1 and in C2S1, indicating medium to high salinity and low alkali water, which can be used for irrigation in most soil and crops with little danger of development of exchangeable sodium and salinity (Figure - 2).

The very high saline water is not suitable for irrigation under ordinary conditions but may be used occasionally under very special circumstances. The low sodium (alkali) water can be used for irrigation on almost all soils with little danger of the development of harmful levels of exchangeable sodium. Out of 51 samples, two samples collected from Muftiganj area fall in the field of C3S2 (high salinity and medium alkali) and C4S4 (very high salinity and very high alkali). Medium sodium water will present an appreciable sodium hazard in fine textured soils having high cation exchange capacity especially under low leaching conditions. High salinity and high alkali water is not suitable for irrigation uses in most of the cases.

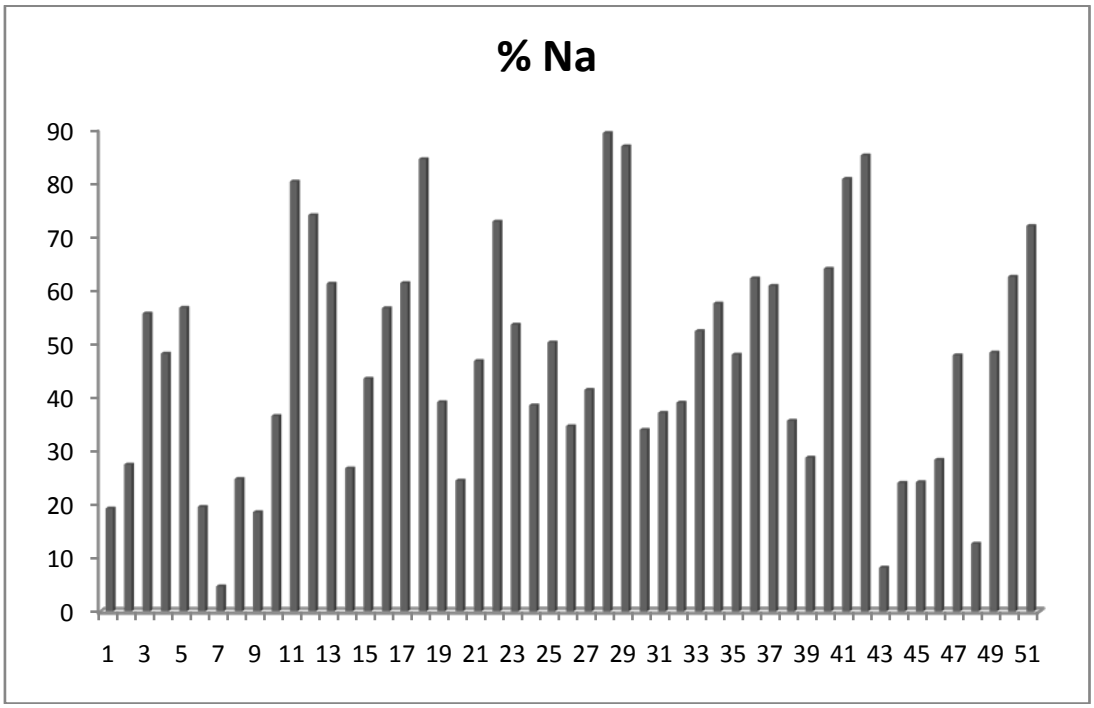

Figure-4: Graphical representation of Na% for irrigation use.

(b) Electrical conductivity (EC) and Sodium percentage (Na %)

Electrical conductivity (EC) and sodium concentration are very important in classifying irrigation water. They include relatively small but important amount of dissolved solids originating from the weathering of the rocks and soils and from the dissolving of lime, gypsum and other salt sources as water flows over or percolate through them. The salts, besides affecting the growth of the plants directly, also affect soil structure, permeability and aeration, which indirectly affect plant growth.

The Na% varies from 2% to 86% (average 42%) in the analyzed water sample of Jaunpur district area. A high sodium percent causes deflocculation and impairment of the tilt and permeability of soil. As per the Indian Standard, maximum sodium of 60% is recommended for irrigation water. Plot of analytical data on diagram relating electrical conductivity and sodium percent shows that the 45% of the water of the Jaunpur district have excellent to permissible quality, which may be used for irrigation purposes. However, about 55% of the water samples have high EC and %Na making it doubtful to unsuitable for irrigation use (Figure - 5).

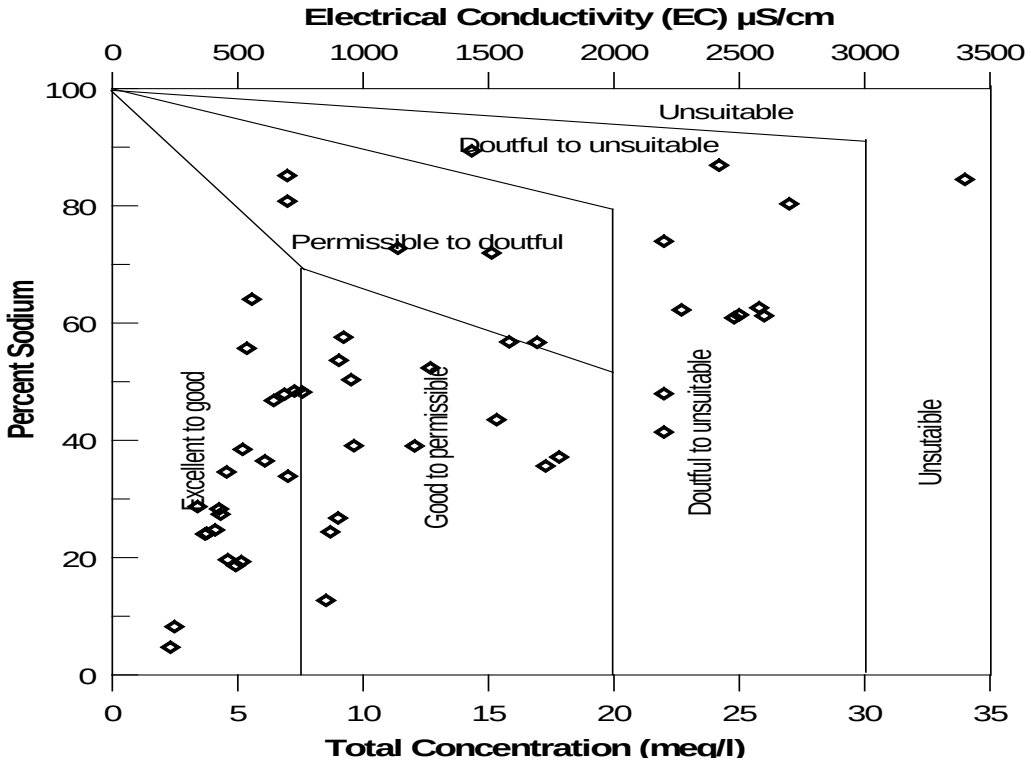

Figure - 5: Plot of Sodium Percent (Na %) Vs Electrical Conductivity (EC)

(c) Residual Sodium Carbonate (RSC)

The quantity of bicarbonate and carbonate in excess of alkaline earths (Ca + Mg) also influence the suitability of water for irrigation purposes. When the sum of carbonates and bicarbonates is in excess of calcium and magnesium, there may be possibility of complete precipitation of Ca and Mg. To quantify the effects of carbonate and bicarbonate, residual sodium carbonate (RSC) has been computed by the equation:

A high value of RSC in water leads to an increase in the adsorption of sodium on soil. Irrigation water having RSC values greater than 5 meq/l are considered harmful to the growth of plants, while water with RSC values above 2.5 meq/l are not considered suitable for irrigation purpose. In most of the analyzed water samples, RSC are found towards higher side (>2.5 meq/l) indicating marginal to unsuitable water for irrigation uses.

(d) Magnesium Hardness (MH):

Magnesium hazard (MH) is another parameter for assessing the suitability of water for irrigation uses. The magnesium hazard (MH) value can be calculated by the following formula:

MH > 50 is considered harmful and unsuitable for irrigation use. In the analyzed water only one sample has the MH value >50 and falls in unsuitable zone.

(e) Permeability Index (PI):

Permeability Index (PI) is another parameter for assessing the suitability of water for irrigation uses. Doneen (1964) classified irrigation waters based on the Permeability Index (PI). PI is defined by:

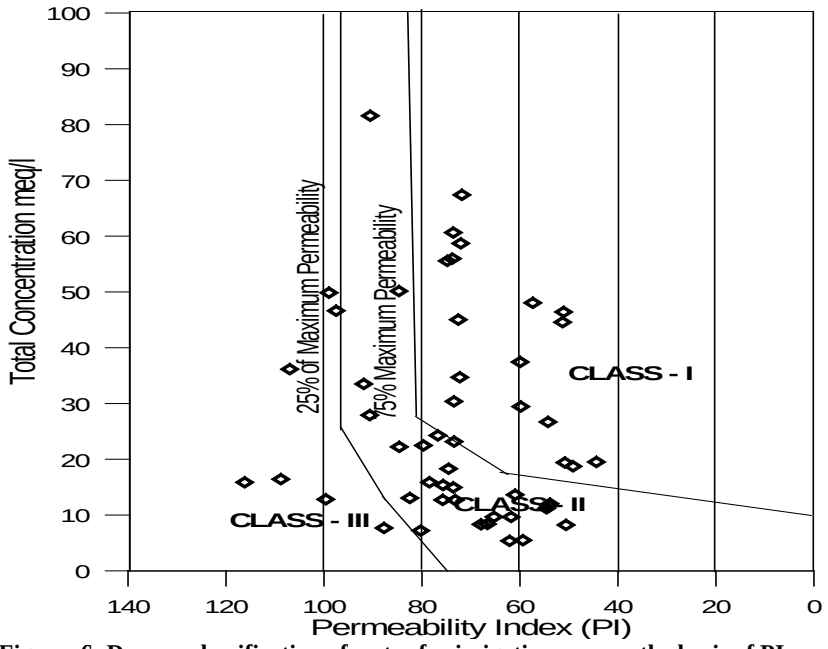

Figure -6: Doneen classification of water for irrigation uses on the basis of PI

Seventeen of the surface water samples fall in Class–I, 51% in Class-II in the Doneen's chart (Domenico and Schwartz 1990), implying that the water is of good quality for irrigation purposes with 75% or more of maximum permeability. However, 15% surface water samples belong to Class-III, i.e. unsuitable category.

CONCLUSION

To achieve the objective of the present study, 51 samples from surface water (rivers, nala, and ponds) resources were collected from different sampling sites of the Jaunpur district area. The samples were collected from rural and sub-urban areas during the months of June 9th 2009. The collected samples were analyzed for pH, conductivity, TDS, major cations (Ca, Mg, Na and K), major anions (HCO_3, F, Cl, SO_4 and NO_3), acidity and alkalinity. The analytical data were evaluated in terms of the chemical characteristics of the water resources of the affected areas of Jaunpur district and its suitability for drinking and irrigation uses. For assessing the suitability of drinking water, the water quality data of the analyzed samples were compared with the prescribed drinking water standard of WHO and BIS (IS:10500). The parameters like %Na, SAR and RSC were calculated for assessment of water for the irrigation uses. The following are the major finding of the present study on surface and subsurface water quality assessment of Jaunpur district area:

1. The pH of the analyzed water samples varies from 6.6 to 9.3, indicating alkaline nature of the surface and sub-surface water. The Electrical Conductivity (EC) value varies from 231 to 3400 $\mu s\ cm^{-1}$.
2. Total dissolve solid (TDS) varied from 203 to 2575 mg/l in surface water samples of the study area.
3. The alkalinity of analyzed water sample varies from 24 to 336 mg/l is good for irrigation due to higher productivity range because productivity is directly proportionally to alkalinity.
4. The acidity of analyzed water samples varies from 27.2 to 508.0 mg/l. In the study areas the minimum concentration were observed in Khutahan Block where as the maximum concentration reported in the Barsathy Block.
5. Higher concentrations of dissolved ions were observed in the water samples collected from Rural and sub-urban sites, especially from Mariyahoo, Barsathi, Rampur, Jalalpur, Kerakat, Suithakala, Khuthan, Jaunpur city area.
6. Samples collected from rural areas have higher concentration of SO_4, Cl and total hardness (TH).
7. The large variation in the EC, TDS and ionic concentration in the surface water of the area may be attributed to variation in geo-chemical process and anthropogenic activities.
8. The cation chemistry indicate that 15% of the water sample are Ca>Mg>Na>K, while 6% belong to Ca>Na>Mg>K and 23% of Na>Ca>Mg>K. Only 4% sample belongs to Na>Ca>K>Mg type.
9. HCO_3 and Cl were the dominant ions in anion chemistry of the water of the

areas. Bicarbonate contributes on an average 67% to the total anions followed by chloride (22%), sulphate (8%), nitrate (2%) and fluoride (1%).

10. The quality assessment shows that in general, the water is suitable for domestic purposes with some exceptions. However, high values of EC, TDS, TH, NO_3 and SO_4 at some site make it unsafe for drinking and irrigation uses.
11. The assessment of water for irrigation uses show that the water is good to permissible quality. However, high values of salinity and sodium adsorption ratio (SAR), Residual Sodium Carbonate (RSC) and Permeability Index (PI) at certain sites restrict its suitability for agriculture uses and needs proper implementation of the water & soil management plan in the area.

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