EUROPEAN JOURNAL OF BIOMEDICAL AND PHARMACEUTICAL SCIENCES

http://www.ejbps.com

ISSN 2349-8870
Volume: 11
Issue: 5
267-275
Year: 2024

# WATER QUALITY ANALYSIS OF PAISWANI RIVER USING GIS – A CASE STUDY

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**Article Received on 22/03/2024** **Article Revised on 11/04/2024** **Article Accepted on 01/05/2024**

## ABSTRACT
The paper presents a case study on the water quality analysis carried out at the Paiswani river. Chitrakoot (Satna, MP) and Chitrakoot district, UP, India. Twelve physico-chemical and biologicals parameters were considered in the analysis. Geographic information system (GIS) is used to represent the spatial distribution of the parameters and raster maps were created. The analysis was carried for pre-monsoon, monsoon and post-monsoon seasons. The water quality index indicated that most of the sampling locations come under good category indicating the suitability of water for human use. Due to the industrialization and agricultural disposal some of the sampling locations became unfit.

**KEYWORDS:** Water quality, spatial approach, GIS.

## INTRODUCTION
Water is one of the most essential natural resources for eco-sustainability and is likely to become critical scarce in the coming decades due to increasing demand, rapid growth of urban populations, development of agriculture and industrial activities especially in semi-arid regions (Hajalilou and Khaleghi, 2009). Variations in availability of water in time, quantity and quality can cause significant fluctuations in the economy of a country. Hence, the conservation, optimum utilization and management of this resource for the betterment of the economic status of the country become paramount (Singh et al., 2009). The definition of water quality is very much depending on the desired use of water. Therefore, different uses require different criteria of water quality as well as standard methods for reporting and comparing results of water analysis (Khodapanah et al., 2009). On the other hand, GIS is very helpful tool for developing solutions for water resources problems to assess in water quality, determining water availability and understanding the natural environment on a local and / or regional scale. From GIS, spatial distribution mapping for various pollutants can be done. The resulting information is very useful for policy makers to take remedial measures (Swarna Latha and Rao, 2010).

The quantity and quality of surface water in a river basin is influenced by natural factors such as rainfall, temperature and weathering of rocks, and anthropogenic changes that cultural natural flow of the river, or alter its hydrochemistry. River and streams are highly heterogeneous at spatial as well as temporal scales, and several investigations have documented this heterogeneity focusing on the physico-chemical dynamics of river. Variation in the quantity and quality of river water is widely studies in the case of several world rivers (Tiwari and Chaturvedi, 2011 and Tiwari et al., 2017).

## MATERIAL AND METHODS
River water samples, collected from 6 different location of Paiswani river, District Chitrakoot and Chitrakoot, Satna District (Table 1) from various river water for winter, summer and post monsoon seasons, were analysis for physico-chemical parameters (pH, EC, total hardness, chloride, total alkalinity, TDS, TS, DO, BOD, COD, total coliform, etc). Parameters physico-chemical and biological will be studied as per method and techniques described by Saxena (1990), APHA (1992) and NEERI (1986).

**Table 1: Name and location of sampling Stations.**

| S.N. | Name of the location/ Name of Sampling Station | Latitudes and longitudes Position of Sampling Station | Altitudes (Mean sea level-Metre) | Reason for selection |
|---|---|---|---|---|
| 1. | Satianusuiya (S1) | N $25^0$ 04' 27.2" E $80^0$ 52' 02.5" | 247 | Bathing places |
| 2. | Sphaticshila (S2) | N $25^0$ 08' 45.5" E $80^0$ 51' 24.2" | 236 | Bathing places |
| 3. | Jankikund (S3) | N $25^0$ 09' 30.7" E $80^0$ 51' 50.6" | 165 | Bathing places |
| 4. | Pramodvan (S4) | N $25^0$ 09' 46.9" E $80^0$ 52' 08.3" | 118 | Bathing places |
| 5. | Ramghat (S5) | N $25^0$ 10' 35.9" E $80^0$ 52' 10.5" | 122 | Bathing places |
| 6. | Karwi (S6) | N $25^0$ 12' 49.7" E $80^0$ 54' 17.2" | 164 | Bathing places |

**Geological Information System**

**Spatial Analysis**

1. The entire methodology has been divided into five steps as follows.
2. Acquisition of required topographic sheet 63 C/16 (1:50000 Scale) thematic map and data.
3. Converting the topographic sheet and the various maps of the study area into digital form.
4. Assigning of ground coordinates to digital database of the previous step by means of georeferencing operation respectively.
5. Digitization of the required themes.
6. Performing various overlay operations on the thematic layers as per the guidelines by making use of GIS environment.

**Maps and Data Acquisition**

Maps and data required were obtained from Geological Survey of India from the concerned government authorities. Data related to site selection and water quality parameters were acquired as per methodologies discussed earlier (Punihal et al., 2002).

**Converting Topographic Sheets and Maps into Digital Form**

The topographic sheet (Figure 1-2), covering the study area at 1:50,000 scale (63 C/16) published by Geographical Survey of India (SOI) was scanned to convert into digital form (Raster).

**Georeferencing**

For carrying out geometric correction, map was georeferenced using Universal Trasverse Mercator (UTM) with Indian (India, Nepal) datum and Everest (India, 1956) ellipsoid using zone no. 44. In the present study 24 points were taken and full second order polynomial was chosen and resampling is done by nearest neighborhood interpolation methods (Mather, 1987; Burrough & McDonnell, 1998: Chen et. at., 2000).


**Figure 1: Image of study area.**

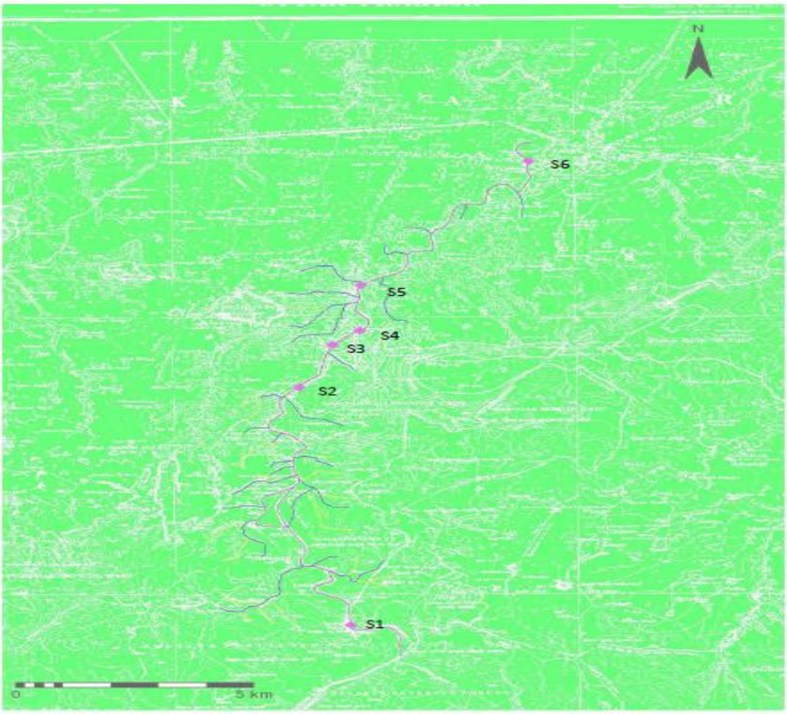


**Figure 2: Toposheet of study area showing sampling sites and Paiswani River stretch.**

**Generation of Thematic Maps**

Thematic Maps covering water quality, contour, drainage, site selection and river pollution stretch were generated from maps with the process of screen digitization in ILWIS 3.7.

**RESULTS AND DISCUSSIONS**

**Geological Information System**

**Thematic Map Generation**

Thematic maps covering contour, drainage and sampling sites were generated with the process of screen digitization in ILWIS 3.7 (Figure 3-4). Digital Elevation Model was also created with the help DEM Hydroprocssing operation (DEM – Figure 5-6). Geographical coordinates (latitude and longitude) were assigned to the spots located depending on the analytical method used for the location. Drainage Distance map was worked out to observe the range of drainage that is 4259 meters to 20293 meter (Figure 7). As per GIS protocol thematic map ware generated to evaluate the status of Paiswani River water quality parameters at six sampling station S1, S2, S3, S4, S5 and S6.

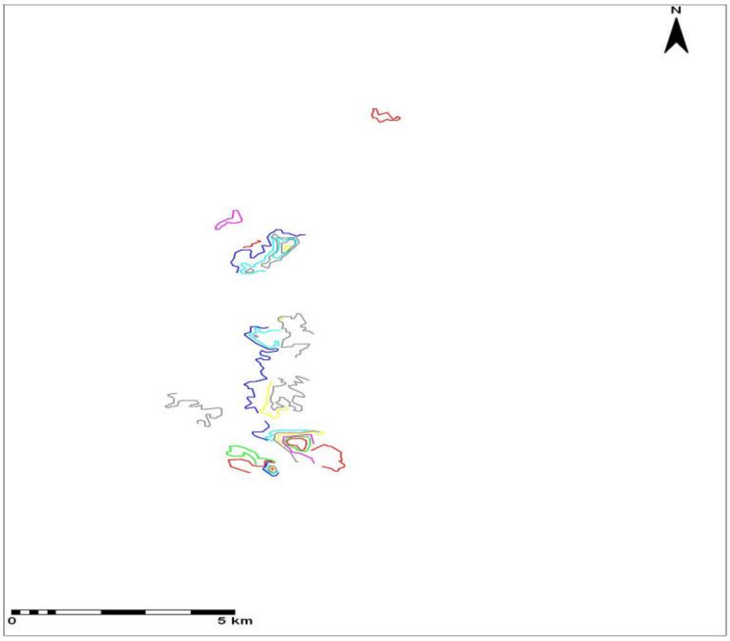


**Figure 3: Contour Map of study area.**

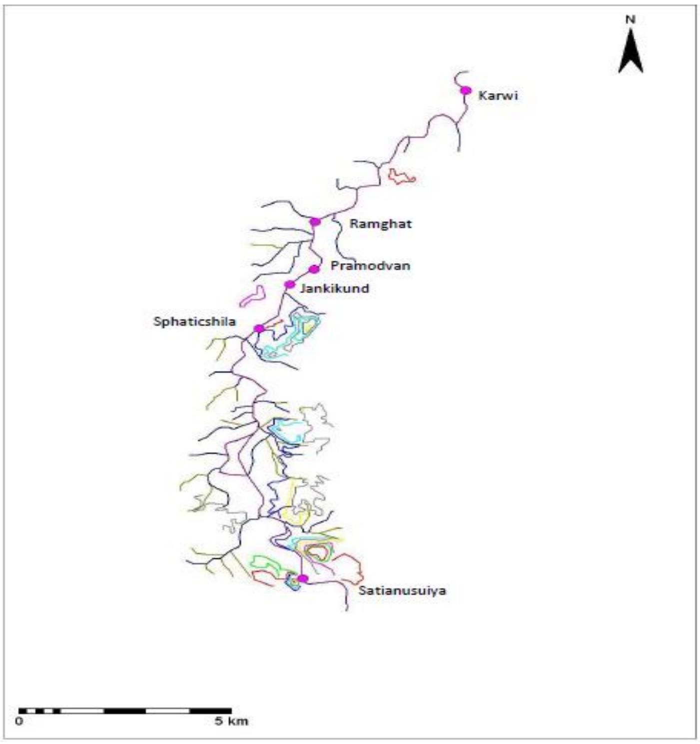


**Figure 4: Map showing Drainage, Contour and Sampling Stations of the study area.**

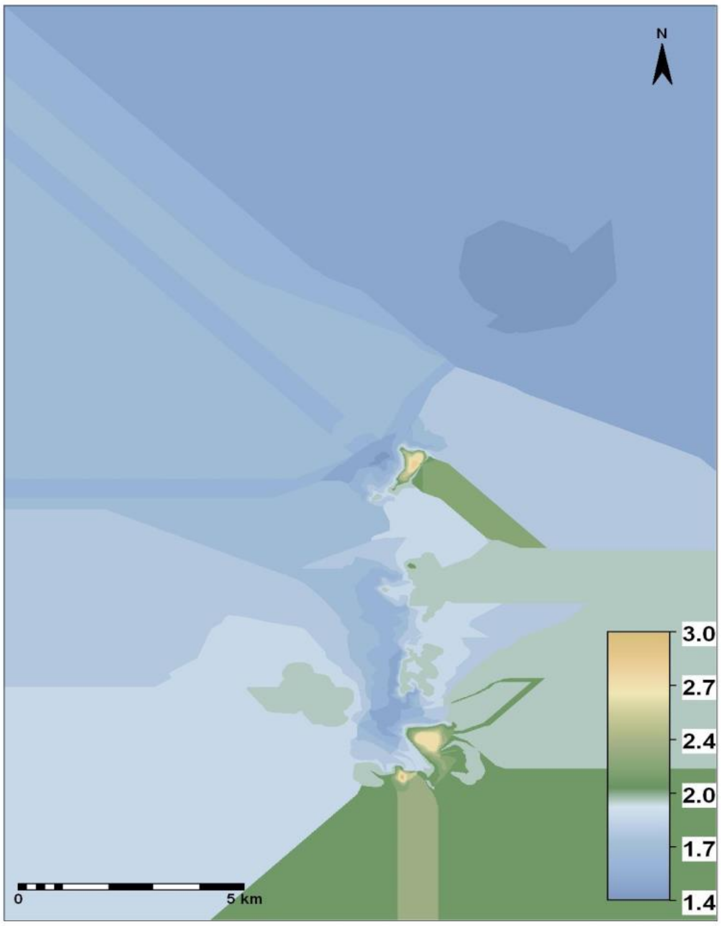


**Figure 5: DEM of study area.**

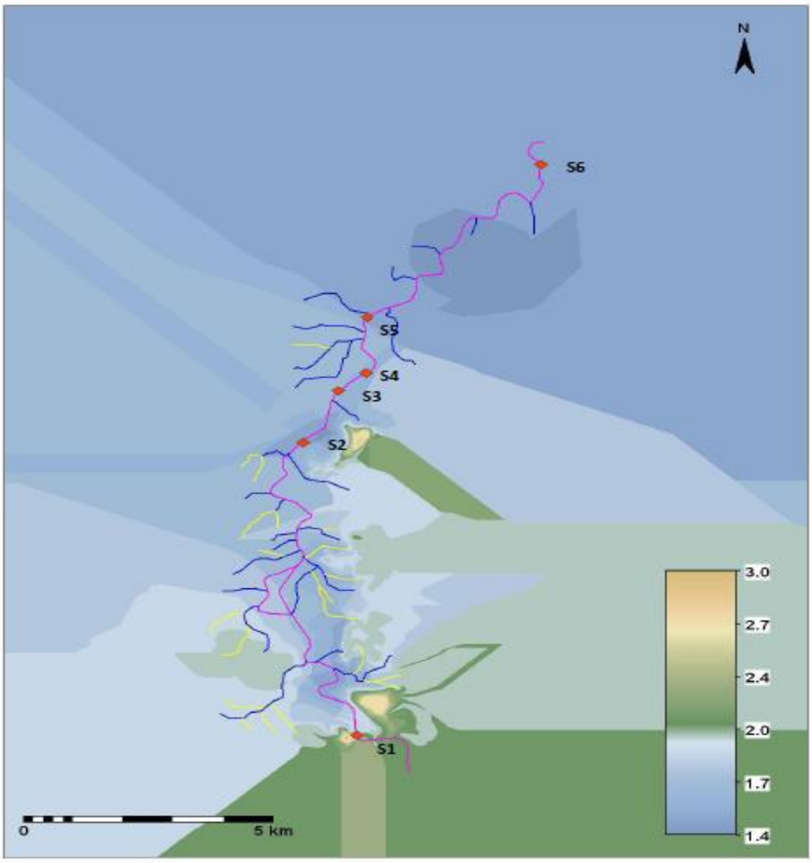


**Figure 6: DEM, Drainage and Contour of the Paiswani River (Showing Sea mean level).**

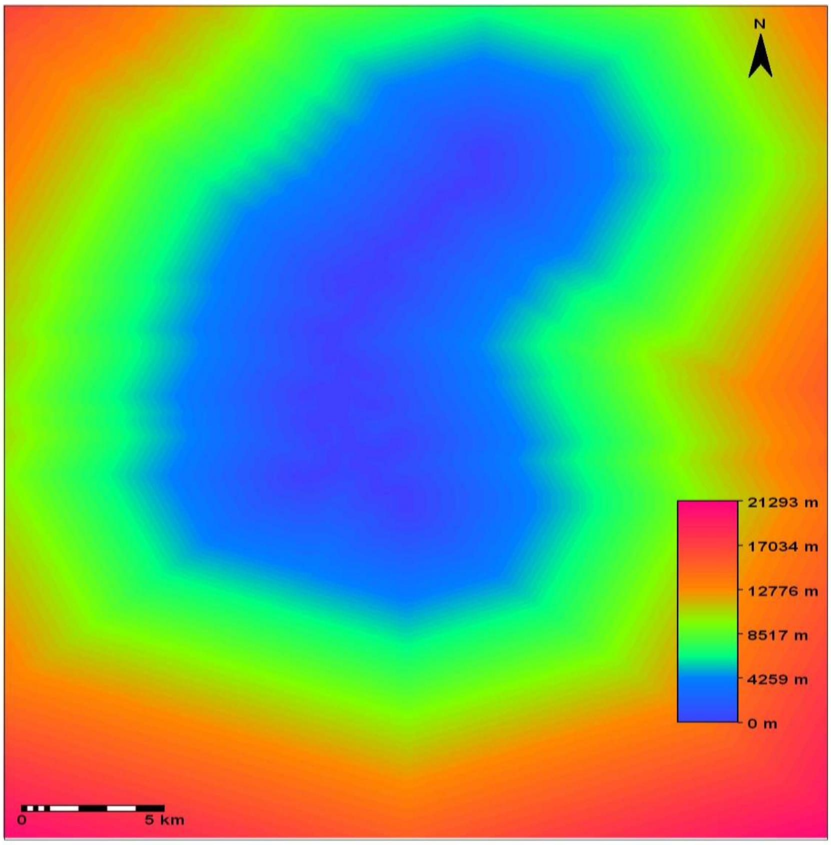


**Figure 7: Drainage distance calculation of the Paiswani River.**

**Spatial Analysis**

Geographic Information Systems (GIS) can be a useful tool for modeling water quality in rivers. Once field data is collected, it can be combined with ancillary data within a GIS. The spatial interpolation capabilities of GIS enable the visualization of spatial relationships within discrete observation data. The observation data can be linked to geographic positions using a Global Positioning System (GPS) and geo-referenced imagery or maps. Spatial interpolation is an effective and commonly used method to create continuous surfaces from a limited number of discrete sampling points.

Geographic Information System (GIS) is gaining importance and widespread acceptance as a tool for decision making / support in the infrastructure, water resources, environmental management, spatial analysis and urban & regional development planning. With the development of GIS, environmental and natural resource management has found a information systems in which data are more readily accessible, more easily combined and more flexibly modified to meet the needs of environmental and natural resource decision making (Bathory et al., 2005).

In current investigation the average value of water temperature of the samples varied from 23.95$^0$C, total dissolved solids in water ranged from 376.60 mg/total solid of the water samples showed variations from 435.23 mg/l. pH of the water samples showed variations from 7.6,electrical conductivity of the samples varied from 480.75µS/cm, total hardness of the waters samples varied from 227.15 mg/l, total alkalinity in water ranged from 204.0 mg/l, chloride content in the water samples varied from 34.28 mg/l, DO ranged from 6.56 mg/l, BOD value of the waters samples varied from 11.16 mg/l, The COD of the waters samples varied from 64.1 mg/l and total coliforms varied from 1484 MPN/100ml correspondingly. The seasonal variation of physical, chemical and biological parameters of Paiswani river is depicted in thematic map (Table 2 & Figure 8).

**Table 2: Physical, chemical and biological parameter of Paiswani River.**

| Sampling Station | Parameters | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | pH | EC (µS/cm | Total Hard-ness mg/l | Total Alkali-nity mg/l | Chlor-ide mg/l | Water Tem. $^0$C | DO mg/l | BOD mg/l | COD mg/l | Total Coliform (MPN/ 100ml) | TDS mg/l | TS mg/l |
| S1 | 7.5 | 482.3 | 249.3 | 215.0 | 28.4 | 23.3 | 6.0 | 8.2 | 52.8 | 713.0 | 376.65 | 430.52 |
| S2 | 7.5 | 480.2 | 228.3 | 201.2 | 30.7 | 25.5 | 6.6 | 8.9 | 56.0 | 755.0 | 364.0 | 384.5 |
| S3 | 7.7 | 481.7 | 227.0 | 200.7 | 30.7 | 23.7 | 7.6 | 9.8 | 62.4 | 1041.0 | 358.33 | 419.0 |
| S4 | 7.9 | 477.7 | 213.0 | 200.7 | 39.0 | 23.7 | 7.6 | 10.7 | 65.6 | 1866.0 | 377.83 | 443.5 |
| S5 | 7.8 | 485.8 | 219.3 | 199.3 | 41.4 | 23.7 | 5.8 | 15.1 | 77.9 | 2566.0 | 415.5 | 494.91 |
| S6 | 7.4 | 476.8 | 226.0 | 207.3 | 35.5 | 23.8 | 5.8 | 14.3 | 69.9 | 1966.0 | 367.33 | 439.0 |
| Average | 7.6 | 480.75 | 227.15 | 204.0 | 34.28 | 23.95 | 6.56 | 11.16 | 64.1 | 1484.0 | 376.60 | 435.23 |

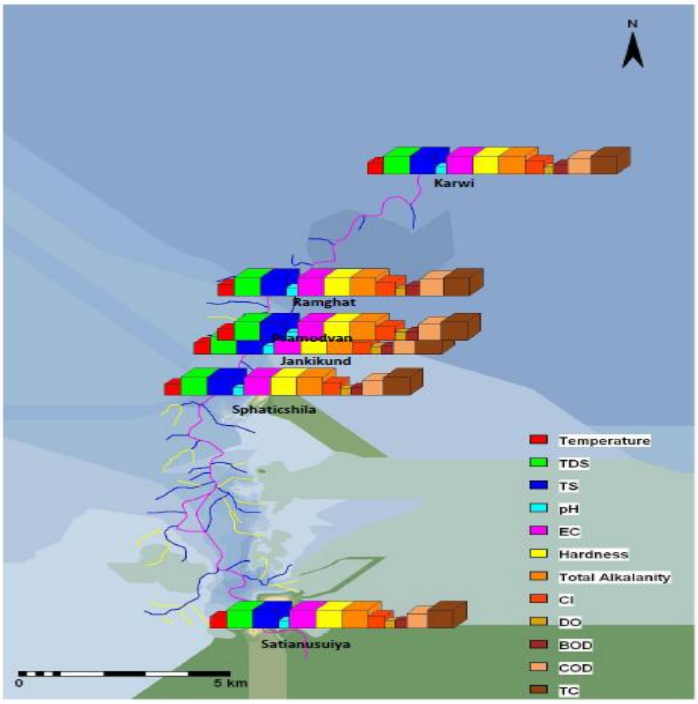


**Figure 8: Water quality parameters (Spatial) with DEM & Drainage of Paiswani River.**

Generally, along the stretch physical parameters temperature, TDS, TS, Chemical parameters pH, DO BOD, COD, and Chloride, total hardness, total alkalinity, EC and biological parameter TC (total coliforms) show slightly increasing trend over the years (2007-2009) in the downstream direction of river flow. Parameters like BOD, COD, total hardness, EC, and total coliforms show much of variation from the mean. However, the water quality readings of DO were slightly decreasing along the downstream direction. The minimum and maximum BOD values during 2007 and 2009 were 1.5 and 40.0 mg/l (monsoon due to rain) whereas the COD values were 38.4 and 96.0 mg/l and total coliforms values 220 and 3000 MPN/100ml. These indicated that the inflow of pollutants to river has been increasing.

GIS were used to organize both spatially and temporally and presenting graphically the water quality/ water pollution of the Paiswani river. For each parameter for two years were presented which included yeas of minimum and maximum value of starting and ending years. The spatial variation of all the parameters showed a steady increase in the water quality towards the downstream direction. This is due to two reasons – (i) the increased flow in the downstream direction and (ii) the increase in concentration of water quality parameters, though inconsistent, downstream due to addition of wastes (domestic wastes, sewage, bathing, animal washing and different type anthropogenic activity by human).

Tripathy and Parikh (1998). Soam and Singh (2002), presented spatial modelling approach to water pollution monitoring in the sugar belt of Maharashtra along the Krishna River, GIS has been utilised in the storage and retrieval of attribute data such as water quality parameters (pollution loads), population density and fertilizers consumption over the spatial database (map) of whole stretch of the river catchments. With the aid of map comparison utility in GIS, pollution map will be compared with the population location maps.

The contents of all pollutants in surface waters were determined for four different seasons between 2007 and 2009 and with these data a Geographic Information System (GIS) has been constructed by using ILWIS 3.7. The organic pollutants, including COD and BOD followed the sharply increasing trends.

Therefore, it could be suggested that for decision makers it can be possible to evaluate a larger stretch without concerning huge set of data structure. Finally best management practices including pollution monitoring and updated data structure in GIS mode would be practiced to reduce the pollution level in the study area.

**Suggestion and recommendation**

Water is recognized not only as a social and environmental liability but also an economic one. Hence in the management of water resources, quality and quantity- acquire priority.

**1. Water Resources Management Strategy**

Development of water management strategy is suggested for monitoring both water allocation and water pollution. Strategy formulations need available data as first priority. The data generated in the present study will be useful for strategy formulation in general and with respect to Madhya Pradesh and Uttar Pradesh in particular. Optimum use of water could be ensured through proper allocation decisions. Water resources development directly affects stream flows water quality **as** well **as** groundwater. The data from the present study contributes to information on ground water conditions and their impacts on human health, and other ecosystems.

**2. Development of water Quality Model**

As a planning tool, mathematical models and GIS have a widely proved efficiency. Use of mathematical models and GIS need to be incorporated in planning sector to assess the measures to be taken to minimize pollution in water bodies.

**3. Development of health policy formulations**

Another major issue is public health, which is related to the quality of drinking water. Enhanced water resources, can lead to increased incidence of diseases due to increased contact between humans and vectors. Data presented on drinking water quality and water borne diseases helps to identify and implement water supply schemes effectively besides sanitation investment schemes. National standards for drinking water can be reviewed and revised depending on the health information data.

**4. Introduction of water quality card**

A 'water quality card', on similar lines of a 'health card' could be introduced for each family to identify the water quality status of the source from which they are drawing the water. The data serves for a quick analysis in identifying the hot- spots of the contamination and other water quality schemes for the ‘Sustainable Water Sector Development’.

**5. Development of tourism policy formulations**

With the emerging trends in tourism area, studies related to Paiswani River water especially in relation to pilgrimage and tourism bear significance. These studies are contributory towards the development of the water quality model. The data contributes to improve information system required for the policy makers on the water supply services.

Concluding this thesis, we have several key recommendations. Water use by all stakeholders, new and old, should be examined with respect to resource efficiency and greater societal impacts. This means the economic, social and environmental benefits derived from the use of water are comparatively examined.

It is also vital that the quality of water in the Paiswani River is monitored on a continuous basis. Monitoring will indicate if parameters start to approach or exceed water guideline limits. This will allow for action to be taken before water quality becomes detrimental to fish health. Monitoring can be achieved effectively through studies such as this one, provided key parameters are measured.

Tying all of these recommendations together is a need for greater public awareness on issues that relate to water in the area of Chitrakoot. Though each stakeholder holds a unique perspective, educating the public is a collective issue that is best addressed through active participation of all water users.

## CONCLUSION

Chloride, electrical conductivity (EC), Total dissolves solids (TDS), Total solids (TS), temperature, dissolved oxygen (DO), pH, total alkalinity, Biological Oxygen Demand (BOD), Chemical Oxygen Demand (COD), total hardness and fecal coliform concentrations in water were determined from samples taken along transects from a canoe ranging from just of the Paiswani River, to approximately 34.5 km. These data were mapped using GIS methods to show the status of river. Necessary charts, graphs, Tables, field photographs, annexure and maps have been provided to support the findings. The contents of all pollutants in surface waters were determined for four different seasons between 2007 and 2009 and with these data a Geographic Information System (GIS) has been constructed by using ILWIS 3.7. The water quality of the Paiswani River under study has confirmed that the pollution load of upstream of Paiswani River is less as compared to downstream. The pollution load especially of Biological Oxygen Demand (BOD) and total coliform increases and dissolved oxygen (DO) decreases towards downstream. Chloride is a good tracer of effluent plume behavior, and showed the extent of the plume in the Paiwani River. Compared to previous years, the extent of the plume for fecal coliform and chloride appeared to be smaller. With respect to water quality guidelines, minimum levels of DO were at the low end of the acceptable range. Although most water quality guidelines were not exceeded in our study, river conditions at the time of the study, such as a high discharge and low temperature, likely increased dilution and dampened diurnal DO fluctuations.

Therefore, it could be suggested that for decision makers it can be possible to evaluate a larger stretch without concerning huge set of data structure. Finally best management practices including pollution monitoring and updated data structure in GIS mode would be practiced to reduce the pollution level in the study area.

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