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Research Paper

QUALITY STATUS STUDY OF RIVER KSHIPRA AT UJJAIN BEFORE ITS LINKAGE WITH NARMADA WATER

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Abstract

Kshipra is Holy River that originates from the Kakri-Badi (Indore) of Madhya Pradesh and flows across Ujjain city (23°18' N, 75°77' E) which is considered to be geographically, historically, geologically, astronomically and astrologically important. Unlike other river of our country the life line of Ujjain is also facing the consequences of various anthropogenic activities that are leading to its quality deterioration. The present study was carried out to assess the quality status of Kshipra water before its proper linkage with river Narmada, so as to have a baseline data for future studies and to plan a management strategy for forthcoming Simhastha (Kumbh) mela during 2016. Water quality was assessed in terms of physical, chemical and microbiological parameters. Four sampling sites (Ghat) viz., *Triveni*,*Gau*,*Ram*, and *Mangalnath*were selected covering almost whole city along with river traverse. Physical parameters included pH, temperature, conductivity and opacity, while chemical parameters assessed were Total Dissolved Solid, Total Suspended Solid, hardness ($Ca^{++}$and Mg^{++})Dissolved Oxygenand BOD.Total coliforms, fecal coliforms, fecal streptococciand Total Viable Count (TVC) were taken as microbial parameters. All parameters were studied following standard protocols. Results reveal that value of all the parameters were above the permissible limits laid by WHO/ CPCB. Present study brings out the urgency and need for the sustainable management of river Kshipra and thereby maintaining sustainability of our society and culture.

Key words: EMB, Total Coliforms.

INTRODUCTION

Water is one of the fundamental requirements of lifethatplays a significant role in sustain of a nation. The available fresh water for human consumption is hardly 0.3 to 0.5 percent of the total water (2.4%) supply on earth and therefore, its judicious use is important [1]. The most important and popular source of the potable water is the River. Various uses of river water can be categorized into two major groups i) abstractive ii) non-abstractive uses. In countries like India rivers play an important role due to the religious sentiments attached to them. Population explosion, urbanization, industrialization and agricultural pollution lead to water contamination which consequently results in measured deterioration of water quality. It is estimated that the global annual risk of contracting infectious diseases from eating raw vegetables irrigated with untreated wastewater is in the range of 5-15% [2].River Kshipra originates in the Vindhya

Range from a hill called "Kakri-Badi" situated at a distance of 11 km from Indore and flows across Ujjain city (**23°18' N, 75°77' E**).This river is 195 km long, out of which 93 km flow through Ujjain. Presently Kshipra river is facing the problems of industrial effluent (through Khan river merger at Triveni and domestic sewage) disposal problem. Also, domestic sewage in the river increases the pathogenic microbial survival. According to Central Pollution Control Board the organic effluent discharged by industries having extremely high BOD and COD values and mainly responsible for deterioration of river water quality. Recently, the study was conducted in Utrakhand's river and found that five studied rivers (Alaknanda,Bhagirathi, Ganga, Mandakini and Yamuna) were polluted[3]. In the same background results of the study conducted on physical, chemical, bacterial and fungal characteristics of Pennarriver indicates that water of the river is highly contaminated and not safe for human use [4].Similar results of water quality deterioration have been reported by other workers [5], [6]. Both developed and the developing countries suffer the impact of pollution due to thedisturbed and disordered economic growth associated with use of natural resources like river [7]**.**

Above mentioned literature indicates that today in India most of the rivers are facing pollution problems mainly due to anthropogenic activities. In order to minimize the pollution problems of such rivers, one of the key stepisto properly study and assess the existing water quality status. Since Kshipra is about to be linked with river Narmada, it is important to have pre linkage baseline data for the future work, therefore the present study has been taken up.

MATERIALS AND METHODS

Methods and materials used in the present study were further divided into following parts:

Site description

Depending on the religious importance and pilgrim pressure, four sites (Ghats) of the river Kshipra, were selected for the present study namely *Triveni,Gau, Ram,* and*Mangalnath*.

Sampling procedure

For collection of water,sterilizedplastic bottles were used. Bottles were washed thoroughly and rinsed with distilled water, for microbial analysis each dry bottle was rinsed with 0.5 ml sodium thiosulphate (10% solution). Water samples were collected from a depth of 30-40 cm by lowering pre-cleaned plastic bottles into the river. Water collected in the air tight bottles was taken to the laboratory for further analysis.

Physical parameters

The important physical characteristics of water includingpH, Temperature, Total Solids, Total Suspended Solids and Total Dissolved Solids were studied followingAPHA [8].

1. **pH:**Assessmentof this parameter was made using electronic pH meter **(Systronic).**
2. **Temperature:** For the measurement of temperatureglass thermometer was used. At the site thermometer was dipped into the water at various points (5-7) and reading was noted.
3. **Total Solids:**
   1. *Total Suspended Solid:*The proportion of suspended solids was determined by filtration of 20 ml sample of water throughWhatmann filter paper. After filtration of sample the filter paper was oven dried at 103° C differences of pre and post filtration weight of filter paper was recorded and calculation was done by this formula:

$$\text{Total Suspended Solids (mg/l)} = \frac{(A - B) \times 1000}{\text{Sample Volume (ml)}}$$

Where, A= Weight of paper + dried residue (mg)B= Weight of filter paper (mg)

   2. *Total Dissolved Solid:*Beaker was washed and weight was taken then 50 ml of sample was taken into the beaker, and evaporated at 103° C. TDS was calculated with following formula:

$$\text{Total Dessolved Solids (mg/l)} = \frac{(A - B) \times 1000}{\text{Sample Volume (ml)}}$$

Where, A= Weight of dried residue + Beaker (mg) andB= Weight of empty beaker (mg)

Chemical Parameters

Few chemical parameters that are considered as pollution indicatorssuchas Dissolved oxygen, Chemical Oxygen Demand and hardness (Ca^{++} and Mg^{++})assessed following standard protocols;

- *Dissolved Oxygen:* DO was determined by Winkler's Method[8].
- *Biochemical Oxygen Demand:*BOD was determined following [8]. For this and ml ratios of water sample (294:6 ml) and double distilled water (285:15 ml) were taken in BOD bottle. Before mixing the distilled water in the above ratio, it was aerated with the help of aerator for two hours. BOD bottles containing water were incubated in the BOD incubator at 21^0 C for five days. Before and after five days incubation, the dissolved oxygen was estimated by Winkler's method.
- *Ca^{++}*and *Mg^{++} hardness*: For the determination of Ca^{++} and Mg^{++} hardnessEDTA Titrimetric method was followed [8].

Biological Parameters

- **Total Coliform:**Most Probable Number (MPN) test was used for estimation of coliform in water sample.Whole process was divided into three steps namely presumptive test, confirmative test and completed test. Media for the tests were Mackonkey broth with Durham's tube, BGLB (**Brilliant Green Lactose Broth**) and EMB (**Eosin Methylene Blue**) agar medium. Acid and Gas production in the presumptive test was marked as positive. In BGLB tubes growth was observed visibly and turbid tube was taken for the next step of MPN test. On EMB agar plates colony morphology was observed and identified.
- **Fecal Coliforms:** This test was used to differentiate fecalcoliforms to coliforms of other sources. One loopful suspension (growth) from positive presumptive tubes of MPN test (Mackonkey Broth) was inoculated in EC broth tubes [8].
- **Fecal streptococci:**Assay for the fecal *streptococci* included presumptive and confirmative test were used.Azide Dextrose Broth tubes were inoculated with water samples. Positive broth tubes were streaked on Pfizer Selective*Enterococcus*(PSE) Agar plates. PSE agar is a selective and differential medium that inhibit proliferation of gram negative bacteria.
- **Total Viable count:**To determine the viable count for aerobic and facultative anaerobic heterotrophic bacteria in water samples, standard plate count procedure was followed [8].

Statistical Analysis

All data collected, compiled and was analyzed for the significant value using *Biostat* Software.

RESULTSANDDISCUSSION

Water bodies play an important role in human development and river is one of the important potable water supplysource. Also, rivers provide land fertility and transportation medium. A considerable amount of pollution in the river is caused by the domestic sources. The domestic pollution is mainly caused by the urban centers. In the present study two sites out of four are depicted in the **Photo-plate 1** and **2.**

(Photo plate 1- Sampling Site of Kshipra riverRamghat)(Photo Plate 2-Sampling Site of Kshipra riverMangalnath)

Physical parameters:

As presented in the **Table-1,** pH ranged between 7.9 to 9.1 at all four sites. But in case of temperature there was only a marginal fluctuation (26-28°C).Opacity was determined visually by comparing the test sample with distilled water and all the samples of four sites were found to be comparatively translucent/turbid.

Table 1: Physical parameters of water of Kshipra

Parameters	TriveniGhat(Site 1)	Gaughat (Site 2)	Ramghat (Site 3)	MangalNath (Site 4)
pH	7.9±.2	8.6±1	9.1±.05	8.6±.03
Temperature	27±1.2	27±2.5	28±1.4	26±3.0
Opacity	Translucent	Translucent	Translucent	Translucent

Chemical parameters:

In the present study results of TS, TSS, Ca^{++} and Mg^{++}, Total Hardness, BOD and DO are presented in **Figure 1, 2, 3, 4, 5,** and **6** respectively. Values at all the sites were found higher than permissible limits. The maximum Total solids were observed at site-1 (1214 mg/L) while it was lowest at the site 4 (874 mg/L). In case of Total Suspended Solids maximum limit was observed in site-1 while lowest at the site-2. In **Figure 3,** Ca and Mg hardness is presented. Calcium hardness was maximum at the site-1 (107 mg/L) and lowest in the site-3 (42.5mg/L). While in the case of Magnesium hardness site-4 (45 mg/L) observed highest value and lowest was at site-2 (20.7 mg/L).

Biological parameters:

Coliforms mainly *E. coli*are the most frequently used organisms as an indicator of the microbiological quality of water. These are groups of gram negative, short rod, non-endospore forming and lactose fermenting bacteria. The term fecal coliform encompasses *Escherichia coli* and a range of other *enterobacteriaceae.* Most *E. coli* are non-pathogenic; however, pathogenic variants also exist.Load of bacterial population in a river mainly depend on factors including: temperature, salinity, and light intensity. Death of fecal coliform is concerned with both solar radiance and water temperature [9].**Table-3** describes the total coliforms, fecal coliforms, fecal streptococci and TVC (total viable count) and reveals that number of cells at all the four sites is considerably high. In the same background **Table-4** reveal the number of *E.coli* and *E.auriginosa*and **Photo-Plate 3**showing the *E.coli* colony morphologyon EMB agar plates.Also,

the MPN method is best for the determination of coliform in the water sample **(Photo-plate 4 and 5).**Again the number is significantly high and supports an alarming situation.

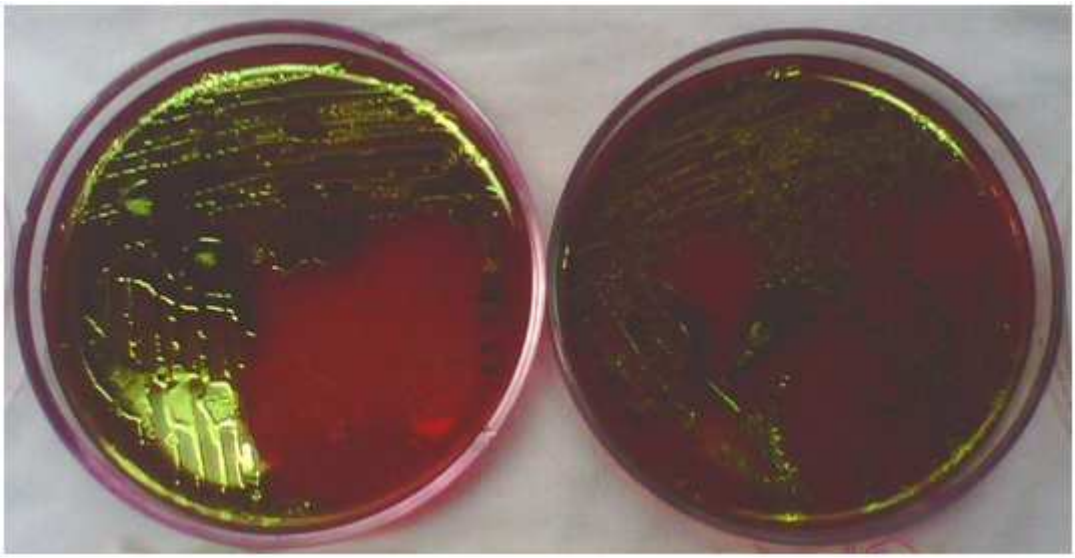


Photo plate 3: EMB Plate showing the *E. coli* growth (Metallic Green sheen colony)

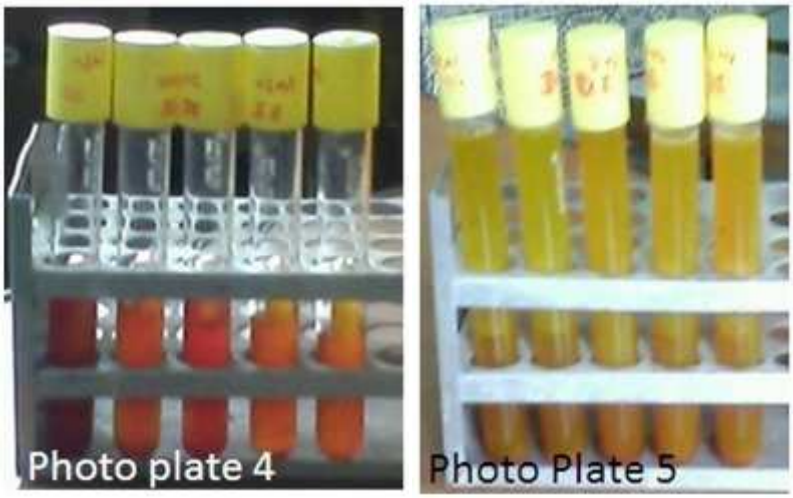
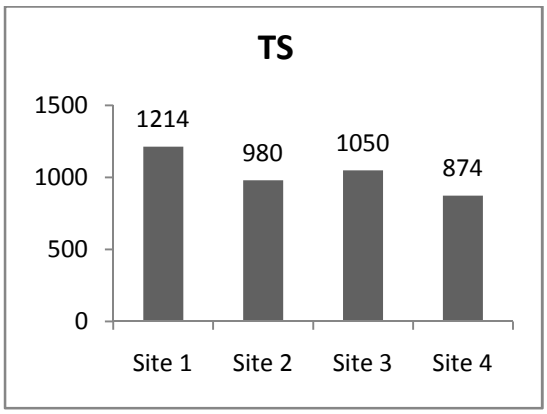
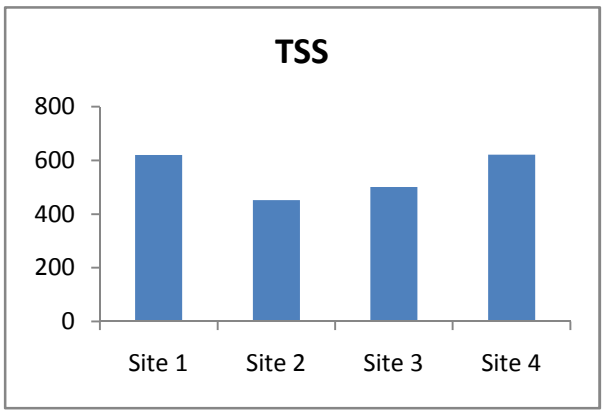


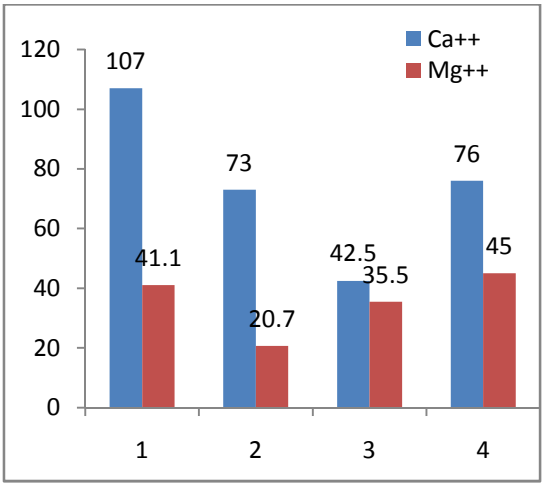
Photo plate 4 & 5: Presumptive and Confirmative test of MPN method (Acid and Gas Production)

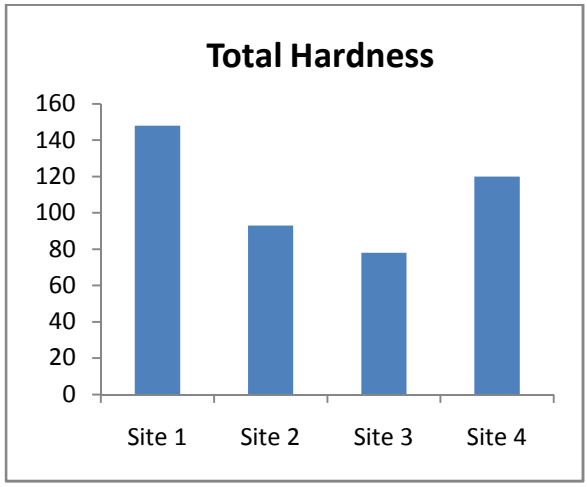


(WHO,2011 Limit: 300 and 600 mg/L)
Figure: 1



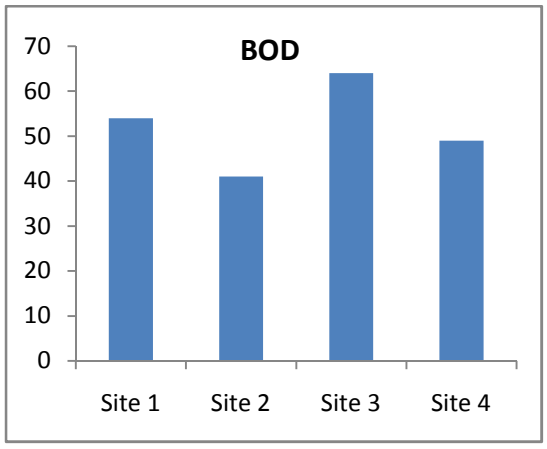
(WHO, 2011 Limit: 300 and 600 mg/L)
Figure 2

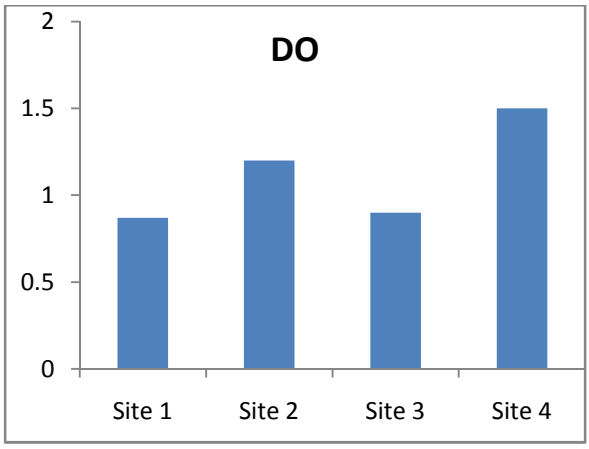




(WHO, 2011 limit 20-40 mg/L)

Figure: 3 Figure 4





(WHO, 2011 limit30mg/L) (WHO, 2011 limit 5mg/L)

Figure: 5 Figure 6

Figure 1 to 6 showing different chemical parameters and their values at all four sites

Table 2: Microbiological characteristics of water of Kshipra River

Parameters	Site 1	Site 2	Site 3	Site 4
Total Coliforms	$25X10^6$	$10X10^6$	$80X10^6$	$45X10^6$
Fecal Coliforms	$64.5X10^4$	$35X10^3$	$21.8X10^3$	$74X10^3$
Fecal Streptococci	$110X10^2$	$71X10^2$	$43X10^2$	$20X10^2$
TVC	$12X10^2$	$20X10^2$	$14X10^2$	$23X10^2$

Table: 3Enumeration of *E.coli* and *Enterobacterauroginosa* on EMB agar (10^{-6} dilution)

Parameters	Site 1	Site 2	Site 3	Site 4
E.coli	$234X 10^6$	$144X10^6$	$203X10^6$	$186X10^6$
E.auroginosa	$82X10^6$	$110X10^7$	$94X10^6$	$145X10^6$

Bathing in river is a common practice in India as per Hindu religious rituals. Bathing, especially mass bathing, significantly contributes disease causing pathogens in the river water and enhance the bacterial load. The religious activities e.g. offering flowers, milk, sweets etc. into the river water further increase organic loading in the river. It is stated that river waters can

contain harmfulmicroorganisms, including bacteria, viruses, parasites, as well as fungi[10],[11]. For detection of microbial contamination total coliforms, fecal coliforms, and fecal streptococci have been reported as pollution indicators [12],[8].The most common fecal coliform (FC) species is *Escherichia coli*. Presence of this bacterium in water is a common indicator of fecal contaminations [13].Researchers studied the physico chemical parameters of Kallani and found that variations were in the physico chemical properties of the water[14].

Kshipra is known for its religious significance and due to anthropogenic activities microbial load also increases in the river water. Every other day there is a mass bathing ritual and pilgrims inflow in Ujjain. Simhastha a big festival season is about to approach in 2016, which will have more than a million pilgrims taking bath in a period of one month. The pressure on river Kshipra can be foreseen. In the present study number of *E.coli* and *E.aeruginosa*wasenumerated on EMB agar plates. At all the four sites *E.coli*was predominant as compared to *E.aeruginosa* (**Table 3**).Similar results were also reported by previous workers [15], [16],[17], [18].Other bacterial indicators have been proposed including *Clostridium, Pseudomonas,* and *Aerobacter,* but their value has been considered questionable or irrelevant. Correlations between coliforms and pathogenic bacteria have been cited frequently, i.e., coliforms vs*Salmonella*[19],[20].Various studieshave shown that individual bacterial population are highly dynamic and can differ strongly in their response to resource availability such as organic carbon, nitrogen, and phosphorus and to food web structure [21],[22], [23],[24].However, waterborne pathogens significantly causegastrointestinal and other disorders in both developed and developing countries [25]. Due to its negative surface charge and relatively low die-off or inactivation rate coefficient, *E. coli* is able to travel long distances underground and is therefore a useful indicator of fecal contamination of groundwater [26]. In the present study also *E.coli* population is significantly high and appears to sustain for longin the river which could lead to ground water contamination in adjoining areas.

Researchers assessed the total coliform levels of river Gongola inNigeria and found that river water was polluted with coliform organisms[27]. Fecal Coliform and *E. coli* concentrations were studied in effluent-dominated streams of the Upper Santa Cruz watershed[28] and found that concentrations were highly variable, especially along urban streams and generally increase with stream flow and precipitation events. According to WHO guideline *E. coli* number should be zero (0) per 100 mL of drinking water [29], and that fecal coliforms (FC) should not exceed 10^3 per 100 mL water to be used in irrigation of crops [30].Field and Samadpour discussed the human health risk assessments and management of water quality in reference to fecal microorganisms [31].

United Nations Environment Programme (1991) [32] has reported that 75% of the population in developing countries lack adequate sanitary facilities and dump most of their waste into the nearest water bodies such as streams, rivers, lakes and estuaries, lagoons and the sea, thereby polluting such water bodies. In recent times, pollution of rivers has increased steadily and polluted rivers have become a norm rather than exception. This situation has arisen as a result of rapid growth of population, increased urbanization, expansion of industrial activities, dumping of domestic and raw sewage into nearby water courses, increased use of fertilizer and agrochemicals[33].

Same is the situation at Ujjain which has seen a very rapid growth in population, developmental activities including housing and urbanization along with agricultural advancement which is leading to a severe deterioration in water quality of the river Kshipra. Adding to the misery river Khan coming from industrial belt of Indore joins Kshipra at Trivenighat and is pouring all its toxic effluents along with sewage water of Indore city.

Present study brings out the urgency and need for the sustainable management of river Kshipra and thereby maintaining sustainability of our society and culture. It also should be noticed in the reference with hygienic circumstances that in 2016 there will be large number of pilgrims gathered in Ujjain for Simhastha (Kumbh) mela.

Also the present study was undertaken for obtaining a baseline data of the river quality, since river Narmada is shortly to be linked with Kshipra. The present data will certainly be useful for better management of the new water system that is going to be formed after Narmada.

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