RESEARCH ARTICLE

MICROBIAL AND PHYSICO- CHEMICAL ASSESSMENT OF THE SACRED RIVER ALAKNANDA AT LOWER STRETCHES, UTTARAKHAND, INDIA

Nidhi Sharma[1]* and R.C. Sharma[2]

[1] Department of Microbiology, J.V. College, Baraut- Baghpat, UP, India
[2] Department of Environmental Sciences, H.N.B. Garhwal University,
Srinagar- Garhwal 246 174, Uttarakhand, India,
Email: nidhsshar@gmail.com

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Abstract : The Alaknanda River is one of the main rivers of Alaknanda sub- system which bubbles out from Alkapuri Glacier. Water quality of the sacred river Alaknanda was evaluated by microbiological and physico- chemical methods. The sampling was undertaken from various sites of lower stretches, including Rudraprayag (530 m a.s.l.), Srinagar (560 m a.s.l.) and Deoprayag upstream (457 m a.s.l.) on the river Alaknanda. A perusal of the data revealed that total viable count ($CFU.ml^{-1}$) was recorded minimum (25,850 $CFU.ml^{-1}$) in winter season and then it increased during summer (45,730 $CFU.ml^{-1}$) and attained peak (56,110 $CFU.ml^{-1}$) during monsoon season, when the maximum degradation in the water quality was observed. Due to the onset of autumn and winter seasons, the quality of water improved substantially and the density of the bacteria decreased (32,120 $CFU.ml^{-1}$) significantly during autumn from the monsoon season. It is revealed that the myriad of physico- chemical environmental variables and nutrient load from various sources in the habitat environment are responsible for density and diversity in the sacred river Alaknanda.

Keywords: Microbiological assessment, physico-chemical assessment, Alaknanda River, Water quality

INTRODUCTION

Study area

The Alaknanda River is one of the main rivers of Alaknanda sub- system which bubbles out from Alkapuri Glacier. A number of small snow-fed streams join the river near Badrinath (3,110 m a.s.l.). Alaknanda in course of its flow meets Dhauli- Ganga at Vishnuprayag (1,460 m a.s.l.) and flows southwest of Chamoli, later joined by the Rudra, Garur, Patel and Birahi Ganga, then in a southerly direction to Nandprayag, where the Nandakini coming from east joins it. It changes its course of flow to the southwest of Karnaprayag, where the Pindar joins it on the left bank at latitude $30^0$19’56” and longitude $79^0$15’29” at an elevation of 2,300 m a.s.l., and thence due west to Rudraprayag, where it receives the Mandakini from the north on the right bank at latitude $30^0$17’10’ and longitude $79^0$1’32’ at an elevation of 1,912 m a.s.l. Further, it changes its course of flow south-west and through Srinagar to Deoprayag, where it is joined by the Bhagirathi and finally named as the river Ganga afterwards. Different important sampling stations identified on the bank of Alaknanda river system at its lower altitudinal stretches were Rudraprayag (530 m a.s.l.), Srinagar (560 m a.s.l.) and Deoprayag upstream (457 m a.s.l.).

MATERIAL AND METHOD

Sample collection

The sampling was undertaken from various sites of lower stretches, including Rudraprayag (530 m a.s.l.), Srinagar (560 m a.s.l.) and Deoprayag upstream (457 m a.s.l.) on the river Alaknanda. Water samples from the sites were collected by dipping the autoclaved sample bottles and closing the cap under water to prevent atmospheric exposure.

Collections of samples were taken from all the sites during the period from October 2005 to September 2007 for the microbiological assessment of the water quality of the river Alaknanda.

Physical and chemical data

The sampling was undertaken from various sites including Rudraprayag (530 m a.s.l.), Srinagar (560 m a.s.l.) and Deoprayag upstream (457 m a.s.l.) on the river Alaknanda. Water samples from these sites were collected by dipping the autoclaved sample bottles and closing the cap under water to prevent atmospheric exposure.

Collections of samples were taken from all the sites during the period from October 2005 to September 2007 for the microbiological and physico- chemical evaluation of the water quality of the river Alaknanda. Physico- chemical and microbiological characteristics of these sites were analyzed following the standard methods outlined in Welch (1952), Golterman *et al.* (1978), Wetzel and Likens (1991) and APHA (1998).

Media and Growth Conditions

Microbial- isolation

SPC agar media (HiMEDIA) was used for the estimation of the numbers of colony forming units (CFUs) of bacteria. Media pH for bacterial isolation was set according to the pH of sampling sites. Media were autoclaved at 121^0C and 15pound/inch^2 pressure for 20 minutes. Pure cultures were obtained by repetitive streaking of differentiated bacteria

*Corresponding Author

colonies on agar media plate. Gram staining was performed for confirmation of purity of the culture.

RESULT

Physico- chemical data

The physical parameters (water temperature, turbidity, transparency, and total dissolved solids) and the chemical parameters (hydrogen ion concentration and dissolved oxygen) of the water of the river Alaknanda from all sampling sites were recorded (Table 1).

The water temperature in the lower altitude zone of the river Alaknanda fluctuated from a minimum 11.63±1.32 ^{0}C (during winters) to a maximum of 18.50±0.80 ^{0}C (during monsoon season). The water was almost clear (17.80±16.27 NTU - 24.39±10.69 NTU) during autumn and winter seasons in the lower altitude zone of the river Alaknanda. However, maximum turbid (176.80±196.86 NTU) water was recorded during monsoon season due to mixing of heavy silt, sand and clay due to heavy precipitation in the catchment areas of the river. The transparency at the high altitude zone of the river Alaknanda was found to be minimum (0.00±0.01 m) during monsoon season and maximum (0.62±0.27 m) during winter season during the entire period of study. The total dissolved solids (TDS) were found to be maximum (150.05±18.93 mg l^{-1}) during monsoon season and minimum (67.07±5.40 mg l^{-1}) in winter season. However, the hydrogen ion concentration (pH) ranged from 7.45±0.21 to 7.85±0.39 during the entire period of study, which shows the slightly alkaline nature of the river Alaknanda. The dissolved oxygen recorded from the high altitude zone of the river Alaknanda revealed that it was maximum (12.62±0.63 mg l^{-1}) in winter and minimum (9.25±0.29 mg l^{-1}) in monsoon season.

Microbial data

A perusal of data on the density and diversity of microbes at all the sites of river Alaknanda revealed that it increased from high to lower altitude. Mean seasonal variations in colony forming units (CFU.ml^{-1}) of bacterial density recorded lower altitudinal stretches of the river Alaknanda have been presented in Figure 2. A perusal of the data revealed that it was recorded minimum (25,850 CFU.ml^{-1}) in winter season and then it increased during summer (45,730 CFU.ml^{-1}) and attained peak (56,110 CFU.ml^{-1}) during monsoon season, when the maximum degradation in the water quality was observed. Due to the onset of autumn and winter seasons, the quality of water improved substantially and the density of the bacteria decreased (32,120 CFU.ml^{-1}) significantly during autumn from the monsoon season.

Statistical Treatment of Data

Regression analyses were made between the colony forming units (CFUs.ml^{-1}) of bacteria and physico-chemical environmental parameters (Fig. 3).

A significant correlation of colony forming units (CFUs.ml^{-1}) of bacteria were found positive with the water temperature, Turbidity, Total dissolved solids (TDS), and Total Hydrogen ion concentration. However, a significant correlation of colony forming units (CFUs.ml^{-1}) of bacteria was found negative with the Transparency and Dissolved oxygen.

DISCUSSION

Heterotrophic bacteria contribute to the cycles of nutrients and carbon in two major ways - by the production of new bacterial biomass (secondary production) and by the remineralization of organic carbon and nutrients. Seasonal variations in physico-chemical environmental variables have played an important role in distribution, periodicity and diversity of microbes. Mokbel & Yamkanamardi (2008) concluded on the basis of statistical treatment of data on temporal variations in the abundance of microbes that several physico- chemical parameters (temperature, pH, TDS, alkalinity *etc.*) were potentially responsible for temporal variations in heterotrophic bacterial abundance.

The water temperature varies with that of the atmospheric temperature in aquatic ecosystem. The temperature was recorded highest during monsoon season and lowest during winter season. At all the sampling sites of Alaknanda, the seasonal mean of bacterial standard plate count (CFU.ml^{-1}) was found to be minimum (25,850 CFU.ml^{-1}) during winter season and maximum (56,110 CFU.ml^{-1}) during monsoon season with a moderate (45,730 CFU.ml^{-1}) during summer season. Then, the density declined (32,120 CFU.ml^{-1}) in autumn season due to improve in the quality of water (Fig. 2).

The present study on the microbial assessment in the Alaknanda River also confirmed the observations made by other workers that the colony forming increased substantially during high temperature, heavy discharge, rain fall and flooding during monsoon season. Major factors affecting the microbiological quality of surface water are discharge of sewage and run- off. McDowell (1984), Zamxaka *et al.* (2004) found relationship between CFUs and discharge and flooding. Increased bacterial abundance at elevated discharge may be attributed input of allochthonous cells or stimulation of bacteria by nutrients and carbon inputs. It is likely that soil, leaf, litter and other substrates in the catchments are sources of bacteria found in stream waters. Wainwright *et al.* (1992) demonstrated that flood plain soil and stream sediments were a significant source of bacteria suspended in a Georgia River. The present study on the high stretches of river Alaknanda also confirmed the observations made by other workers that the colony forming units increased substantially during high temperature, heavy discharge, rain fall and flooding during monsoon season.

Turbidity was found to be minimum during autumn and winter seasons and maximum in monsoon season at all the sampling sites of the river Alaknanda. However, turbidity can interfere with disinfection and provide a medium for microbial growth. High turbidity can provide food and shelter for pathogens. However, a positive correlation was found between turbidity and total bacterial colony forming units in the river Alaknanda.

Transparency was found to be low in autumn and winter seasons at all sampling sites of river. Low visibility prevailed for a brief period during the summer and monsoon seasons. The reduced transparency may be due to silt carried by monsoon rains and snow melting in the higher reaches. The increased transparency in autumn and winter seasons may be due to the absence of the rains and thus run-off as well as gradual settling of suspended particles. However, a negative correlation was found between transparency and total bacterial colony forming units at all the sites of the rivers of Garhwal Himalaya.

Total dissolved solids (TDS) denote mainly the various kinds of minerals present in water. That may be composed mainly of carbomates, bicarbonates, chlorides, sulphates, phosphates and nitrates of Calcium, Magnesium, Sodium and Potassium. TDS was found to be minimum in winter season and maximum during monsoon season at all sampling sites of the river Alaknanda River. The increasing pattern in monsoon season may be due to addition of inorganic salts and organic matter carried along with rain water and surface run- off during monsoon season.

pH is the measure of the intensity of acidity or alkalinity and measures the concentration of hydrogen ion concentration in water. The distribution of hydrogen ion concentration (pH) was found to be moderate and remain slightly alkaline throughout the year at all the sampling sites of the river Alaknanda. However, a negative correlation was found between pH and colony forming units of bacteria. Organic matter contents of water and sample showed its highest values in winter months, where pH values did not perform any regular seasonal variations.

Dissolved oxygen (DO) is one of the most important chemical parameters, which reflects the physical and biological processes prevailing in the waters. It was recorded maximum during winter season and minimum during summer and monsoon seasons. However, a negative correlation was found between DO and colony forming units of bacteria.

Keeping in view, the above discussion, it is concluded that the myriad of physico- chemical environmental variables and nutrient load from various sources in the habitat environment are responsible for density and diversity in the sacred river Alaknanda. The settlement of people nearby the river stretches, open defecation, several Hindu rituals, traditions and beliefs and several anthropogenic activities might have contributed to this. Therefore, remedial measures in terms of control of discharge of untreated sewage, ban on dumping of solid waste in to the river and regulation of excess human interference are urgently required for improving the water quality of sacred river Alaknanda.

Table 1. Mean ($\overline{X}$ ±SD) seasonal variations in physico-chemical environmental variables at low altitudinal (457- 530 m a.s.l.) stretches of Alaknanda River

Parameters	**Autumn (Oct-Nov)**	**Winter (Dec-March)**	**Summer (April-Jun)**	**Monsoon (Jul-Sep)**
Water Temperature (^{0}C)	15.00±1.42	11.63±1.32	17.80±1.87	18.50±0.80
Turbidity (NTU)	17.80±16.27	24.39±10.69	84.50±96.35	176.80±196.86
Transparency (m)	0.45±0.26	0.62±0.27	0.17±0.11	0.00±0.01
TDS (mg l^{-1})	72.00±3.40	67.07±5.40	86.00±2.83	150.05±18.93
pH	7.70±0.04	7.45±0.21	7.65±0.08	7.85±0.39
Dissolved Oxygen (mg l^{-1})	8.55±0.92	12.62±0.63	9.62±0.30	9.25±0.29

Fig. 2. Mean ($\overline{X}$ ±SD) seasonal variations in colony forming units (CFU.ml^{-1}) of bacteria in lower altitude zones of the river Alaknanda

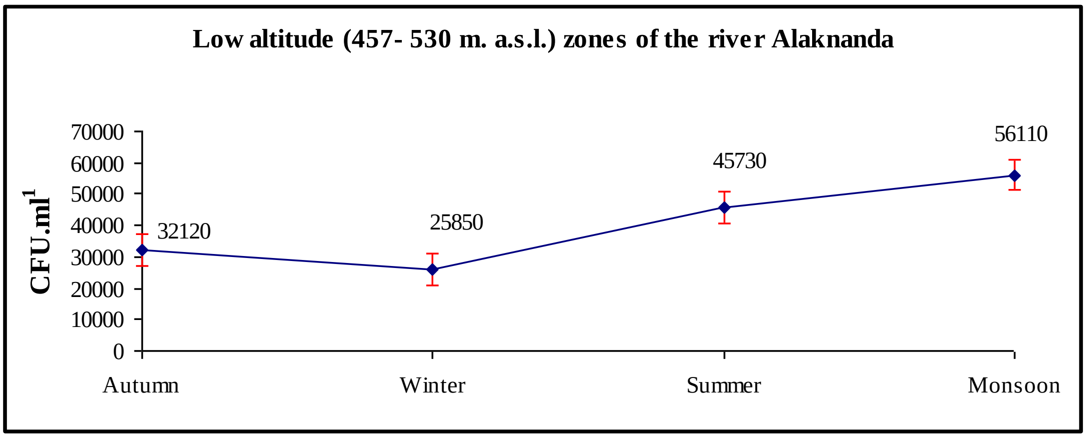
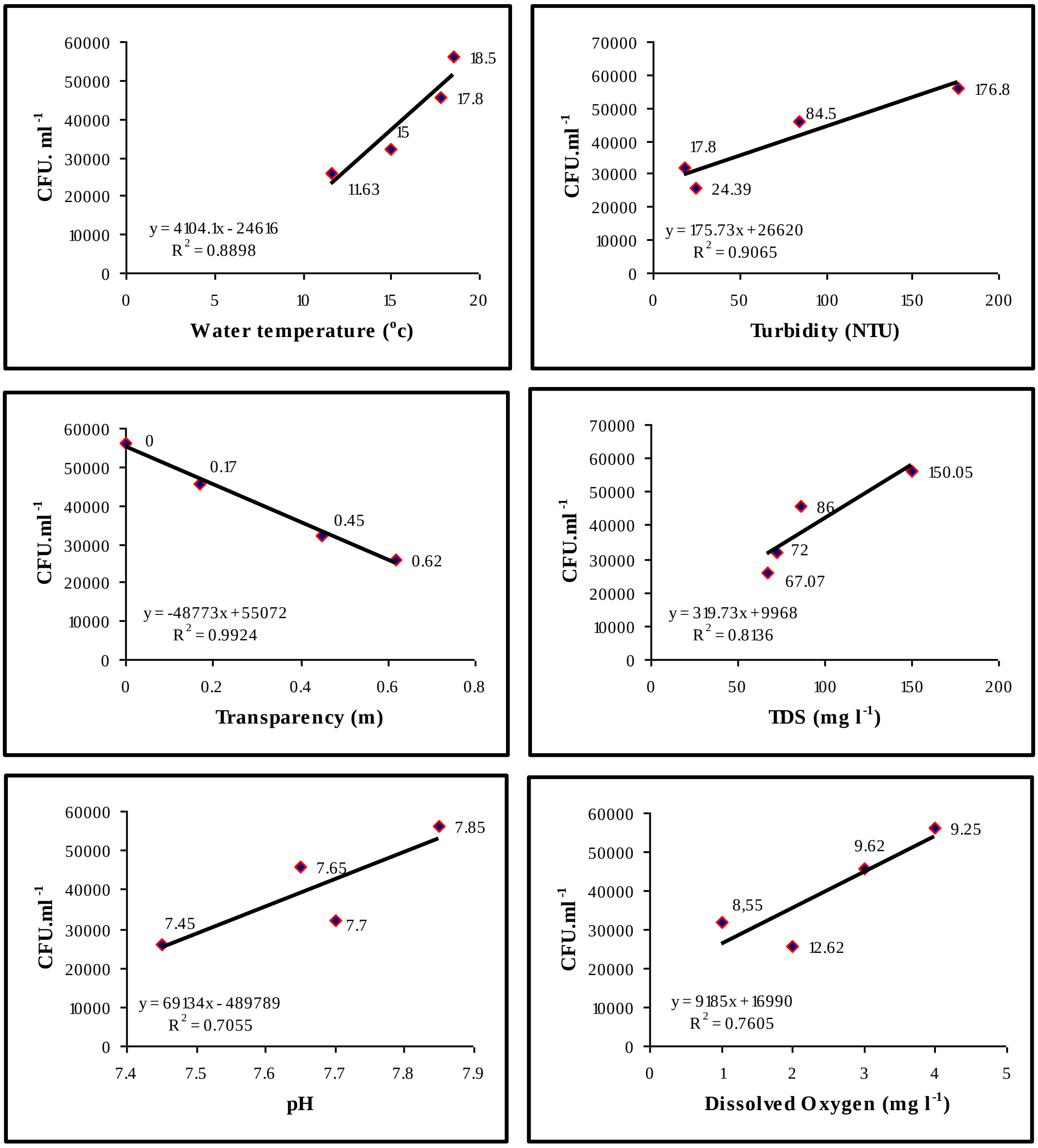


Fig. 3. Regression line plotted against the colony forming units (CFU.ml^{-1}) of bacteria and physico- chemical environmental variables of the lower altitude zones of the Alaknanda River



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