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Physical, Chemical and Bacteriological Study of Water from Rivers of Uttarakhand

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ABSTRACT This study carried out in the month of April-June (2009) for which five rivers were chosen i.e. Alaknanda (A), Bhagirathi (B), Ganga (G), Mandakini (M) and Yamuna (Y). Water samples were collected from nine monitoring stations viz. Devprayag (2), Gangotri (1), Haridwar (2), Rudraprayag (2), Dakpathar (1) and Yamunotri (1). The samples were analyzed for physical, chemical and microbiological parameters. The sample temperatures ranged from 7.8 - 28^{0}C, pH from 7.02 - 8.16, turbidity from 1-15 NTU, DO from 6.3 – 10 mg/l and BOD from 1.4 - 4.5 mg/l. The rivers at Gangotri and Yamunotri showed nil BOD. COD ranged from 2.9 - 34.2 mg/L, total alkalinity from 32-118 mg/l and total hardness from 42 - 194 mg/L. All samples showed permissible limit except samples of Haridwar. All samples were positive for E. *coli,* which indicates fecal pollution of water. The result showed that Brahma Kund in Haridwar, a famous tourist places, is most polluted.

INTRODUCTION

Uttarakhand is bounded by Himalayas in the north, Shivalik hills in south, Ganga in the east and Yamuna in the west. It has a moderate climate. Maximum temperature in summers is around 36^{o}C while the minimum temperature may fall to 5^{o}C in winters. Summers last from April to July while winter lasts from November to February.

With the rapid development in agriculture, mining, urbanization, and industrialization activities, the river water contamination with hazardous waste and wastewater is becoming a common phenomenon. The water quality and human health are closely related. The domestic waste from each building along with the effluent of small scale industries is disposed off into the open drains and gutters which ultimately enter into the rivers. The quality of water is mainly deteriorated by human activities. Nowadays, many industries have developed in Uttarakhand state viz. pharmaceutical, textiles, toy making, colouring etc. They use dispose the waste directly or indirectly into the river water, which affects the BOD, COD, turbidity and also causes the physico-chemical changes. Rivers are getting contaminated due to waste disposing into them. Waste comprises liquid waste discharged by domestic residences, commercial properties, industry or agriculture and can encompass a wide range of potential contaminants and concentrations (APHA 1998). In the most common usage, it refers to the municipal wastewater that contains a broad spectrum of contaminants resulting from the mixing of wastewater from different sources. Sewage is created by residences, institutions, hospitals and commercial and industrial establishments (APHA 1998). Raw influent includes household waste liquid from toilets, baths, showers, kitchens, sinks, and so forth that is disposed of via sewers. In many areas, sewage also includes liquid waste from industry and commerce. As rainfall runs over the surface of roofs and the ground, it may pick up various contaminants including soil particles and other sediment, heavy metals, organic compounds animal waste and oil and grease (FWPCA 1998). Consequently, the problem was taken up when effluents of these industries go into the water system and change the physico-chemical quality of water and make it unfit for drinking and other uses. Since all natural waterways contain bacteria and nutrients, almost any waste compounds introduced into such waterways will initiate biochemical reactions. These biochemical reactions are measured as BOD and COD in laboratory (Tchobanoglous et al. 2003). Both the BOD and COD tests are a measure of the relative oxygen-depletion effect of a waste contaminant. Both have been widely adopted as a measure of pollution effect. The BOD test measures the oxygen demand of biodegradable pollutants whereas the COD test measures the oxygen demand of oxidizable pollutants. Disposal of wastewaters from an industrial plant is a difficult and costly problem (Clair 2003). Most petroleum refineries, chemical and petrochemical plants have onsite facilities to treat their wastewaters so that the pollutant concentrations in the treated wastewater comply with the local or national regulations regarding disposal of wastewaters into community treatment plants or into rivers, lakes or oceans (Tchobanoglous et al. 2003). Physically, wastewater is usually characterized by grey colour, musty odour, 0.1% solid content and 99.9% water content (Massoud and Ahmad 2005). The solids can be suspended 30% as well as dissolved solids which are about 70%. Dissolved solids can be precipitated by chemical and biological processes. From a physical point of view, the suspended solids can lead to the development of sludge deposits and anaerobic conditions when discharged into the receiving environment (Maiti 2004). Chemically, wastewater is composed of organic and inorganic compounds as well as various gases. Organic components may consist of carbohydrates, proteins, fats and greases, surfactants, oils, pesticides, phenols etc. (Tchobanoglous et al. 2003; Maiti 2004).

Drinking water treatment efforts can become weighed down when water resources are heavily polluted by wastewater microorganism species. Pathogenic viruses, bacteria, protozoa and helminthes and other wastewater microorganism species, may be present in raw municipal wastewater and will survive in the environment longer periods (Mane et al. 2005). Sewage pathogens may be present in wastewater at much lower levels than the coliform group of bacteria, which are much easy to identify and enumerate as number of total Coliforms per 100 ml (Feng and Weagant 2002). Various wastewater microorganism species have an adverse impact on human health. Some illnesses from wastewater-related sources are relatively common (WHO 1999). The objective of this study was to check the physical and chemical parameters of the river samples and to find the degree of pollution in them.

METHODS

Water samples were collected from five rivers of Uttarakhand from various regions. The places from where the samples were collected include Devprayag, Gangotri. Haridwar, Rudra-prayag, Dakpathar and Yamunotri. The rivers for this study were: Alaknanda (A), Bhagirathi (B), Ganga (G), Mandakini (M) and Yamuna (Y). Water samples were collected once every month during April- June from two sites-middle of the river stretch and discharge point at nine monitoring stations viz. Har ki Pauri and Brahma Kund (Haridwar) river Ganga, Rudrapryag river Alaknanda and Mandakini, Devprayag river Alaknanda and Bhagirathi, Dakpathar and Yamunotri river Yamuna and Gangotri river Bhagirathi and samples coded as AR, AD, BD, BG, GH, GB, MR, YD and YY.

The water samples were collected in pre-rinsed clean one liter polythene bottle having double stopper facility to its full capacity without entrapping air bubbles inside it. When the water samples from all the monitoring stations were received, systematic analysis of the water samples was undertaken. For analysis of samples, methods followed were of APHA 1998. Temperature, pH and turbidity were measured by thermometer, digital pH meter (NIG 333) and UV-VIS Spectrophotometer. Total alkalinity, total hardness, DO, BOD and COD was measured by titration method. Microbial analysis was done. After growing in mix culture, they were inoculated in selective media viz. EMB agar, Brain Heart infusion agar, Mac Conkey agar, Mannitiol Salt agar, and Nutrient agar for isolation of different microorganisms in the rivers' water samples. The various morphological characteristics of recovered isolates viz., colony morphological (Colour, Shape, Arrangement and Gram staining) and the biochemical tests carried out for identification of isolates (Holt et al. 1994).

RESULTS AND DISCUSSION

The most common physical assessment of water quality is the measurement of temperature. Temperature impacts both the chemical and biological characteristics of surface water. All rivers of study had normal pH range, the pH values were 7.59 and 7.53 at Har ki Pauri and Brahma Kund in river Ganga Haridwar, 7.35 and 7.66 at Rudrapryag in river Alaknanda and Mandakini repectively, 7.6 and 7.82 at Devprayag in river Alaknanda and Bhagirathi, 8.16

and 7.03 at Dakpathar and Yamunotri in river Yamuna and 7.02 at Gangotri in river Bhagirathi (Table 1). The pH is measure of the intensity of acidity or alkalinity and the concentration of hydrogen ion in water. pH has no direct adverse effects on health, however, higher values of pH hasten the scale formation in water heating apparatus and also reduce germicidal potential of chloride. High pH induces the formation of trihalomethanes which are toxic (Kumar et al. 2010). pH affects the dissolved oxygen level in the water, photosynthesis of aquatic plants, metabolic rates of aquatic organisms and the sensitivity of these organisms to pollution, parasites and disease (FWPCA 1968). Most rivers have a neutral to slightly basic pH of 6.5 to 8.5. If stream water has a pH less than 5.5, it may be too acidic for fish to survive in, while stream water with a pH greater than 8.6 may be too basic. A change in stream water pH can also affect aquatic life indirectly by altering other aspects of water chemistry e.g. low pH levels can increase the solubility of certain heavy metals. This allows the metals to be more easily absorbed by aquatic organisms (Schlesinger 1991).

Turbidity of all nine monitoring stations was listed in table 1. The water of river Ganga at Brahma Kund Haridwar was most turbid as turbidity measured 15 NTU, whereas at other places it was range from 1 – 7 NTU. Turbidity, measure of water clarity, tells the degree to which light entering a column of water is scattered by suspended solids. Suspended solids include things such as mud, algae, detritus, and fecal material. Factors contributing to water turbidity include soil erosion, elevated nutrient inputs that stimulate algal blooms, waste discharge, and an abundance of bottom feeders that stir up sediments (Schlesinger 1991). As water becomes more turbid, less sunlight is able to penetrate its surface, therefore the amount of photosynthesis that can decrease. This results in a decrease in the amount of oxygen produced by aquatic plants. In addition, suspended materials absorb heat from sunlight and raise the water temperature. This also limits the amount of dissolved oxygen water can hold (Merritts 1998).

The values of alkalinity listed in table 1. It was in normal and in permissible limit, ranges from 32-118 mg/l. Alkalinity is measured to determine the ability of a stream to resist changes in pH. That is to say alkalinity allows

Table 1: Physico-chemical analysis of water (mg/l except pH)

Parameters/Samples	*GH*	*GB*	*AR*	*MR*	*AD*	*BD*	*YD*	*BG*	*YY*
Name of Water Body	Ganga	Ganga	Alaknanda	Mandakini	Alaknanda	Bagirathi	Yammuna	Bhagirathi	Yamuna
Location	Har ki Pauri	Brahma Kund	Rudra Pryag	Rudra Pryag	Devprayag	Devprayag	Dakpathar	Gangotri	Yamunotri
City	Haridwar	Haridwar	Rudra Pryag	Rudra Pryag	Tehri Garhwal	Tehri Garhwal	Dehradun	Uttarkashi	Uttarkashi
Weather	Clear	Clear	Clear	Clear	Clear	Clear	Clear	Clear	Clear
Colour	Clear	Turbid	Clear	Clear	Clear	Clear	Clear	Clear	Clear
Odour	Odourless	Odourless	Odourless	Odourless	Odourless	Odourless	Odourless	Odourless	Odourless
Temperature	27	28	18.4	18.4	8.2	22	20	7.8	10
pH	7.59	7.53	7.35	7.66	7.6	7.82	8.16	7.02	7.03
Dissolved Oxygen (mg/L)	8.7	6.3	8	8.6	8.2	9	8.2	10	9
B.O.D (mg/L)	2.2	4.5	2.8	2.4	1.4	2.8	3.8	Nil	Nil
C.O.D (mg/L)	11.2	34.2	11.4	9.5	5.8	12.2	28	3.2	2.9
Turbidity (NTU)	5	15	3	3	2	3	7	1	1
Total Alkalinity	94	94	56	86	72	84	118	38	32
Total Hardness	158	192	82	84	92	104	194	58	42
Calcium as $CaCO_3$	84	98	71	56	42	64	84	34	32
Magnesium as $MgCO_3$	74	94	11	28	50	40	89	24	10

Abbreviations- AR=Alaknanda at Rudraprayag, AD= Alaknanda at Devprayag, BD=Bhagirsthi at Devprayag, BG=Bhagirathi at Gangotri, GH= Ganga at Harki Pauri, GB=Ganga at Brahma Kund, MR= Mandakini at Rudraprayag, YD= Yamuna at Dakpathar, YY=Yamuna at Yamunotri scientists to determine a stream's buffering capacity (FWPCA 1968). Alkalinity values of 20-200 ppm are common in freshwater ecosystems. Alkalinity levels below 10 ppm indicate poorly buffered streams. These streams are the least capable of resisting changes in pH; therefore they are most susceptible to problems which occur as a result of acidic pollutants (Merritts 1998). Alkalinity results from the dissolution of calcium carbonate ($CaCO_3$) from limestone bedrock which is eroded during the natural processes of weathering. The carbon dioxide (CO_2) released from the calcium carbonate into the stream water undergoes several equilibrium reactions (Schlesinger 1991).

Total hardness of river water ranged 42-194 mg/l (Table 1), which showed the desirable limit as per Indian standard (ICMR 1996). Calcium carbonate and magnesium carbonate were in range from 32-98 and 10-94 mg/l respectively. Total hardness of water is due to the presence of bicarbonate, sulphates, chloride, and nitrates of Ca and Mg (Kumar et al. 2010). Maximum permissible limit for total hardness is 600 mg/l as per Indian standards. Total hardness recorded for waste water is ranged between 50-200 mg/L. Hardness has got no adverse effect on human health. Water with hardness above 200 mg/l may cause scale deposition in the water distribution system and more soap consumption.

BOD or biochemical oxygen demand represents the amount of oxygen that microbes need to stabilize biologically oxidizable matter. BOD range varies from 1.4 - 4.5 mg/l (Table 1) in river samples. Desirable limit for BOD is 4.0 mg/land permissible limit is 6.0 mg/l according to Indian standards. BOD demand below 3 mg/lor less is required for the best use.

The chemical oxygen demand (COD) ranged from 2.9 – 34.2 mg/l (Table 1). The test is commonly used to indirectly measure the amount of organic compounds in water. Most applications of COD determine the amount of organic pollutants found in surface water, making COD a useful measure of water quality. It is expressed in milligrams per liter (mg/l), which indicates the mass of oxygen consumed per liter of solution (Clair 2003).

Bacteriological analysis showed the four mic-robes in river water samples. All samples had E. coli, as indicator of fecal pollution (Table 2). *Staphylococcus aureus* was found in six samples (GH, GB, AR, AD, BD and YY). *Bacillus cereus* was present in four samples (GB, AR, AD and YD) and *Pseudomonas spp* in three samples viz. GH, GB and MR (Table 2).

Escherichia coli are the most widely adopted indicator of fecal pollution and they can also be isolated and identified simply, with their numbers usually being given in the form of fecal Coliforms (FC)/100 ml of wastewater (De Boer 2000). Outbreaks of these diseases can occur as a result of, drinking water from wells polluted by a combination of different wastewater microorganism species, eating contaminated fish, or indulging in recreational activities in polluted water bodies containing water borne pathogen. *E. coli* cause urinary tract infection and diarrhea and *Bacillus* can cause the anthrax. *Pseudomonas aeruginosa* is a common bacterium which can cause disease in animals and humans (Balcht 1994). *Pseudomonas* can, in rare circumstances, cause community-acquired pneumonias as well as ventilator-associated pneumonias, being one of the most common agents isolated in several studies (Fine et al. 1996). *Staphylococcus aureus* is the most common cause of staph infections. It is a spherical bacterium, frequently found in the nose and skin of a person. *S. aureus* can cause a range of illnesses from minor skin infections, such as pimples, impetigo, boils, cellulitis folliculitis, furuncles, carbuncles, scalded skin syndrome and abscesses, to life-threatening diseases such as pneumonia, meningitis, osteomyelitis, endocarditis, toxic shock syndrome, and septicemia. Its incidence is from skin, soft tissue, respiratory, bone, joint, endovascular to wound infections (Fine et al. 1996).

Table 2: Microbiological analysis of water samples

Microorganisms	*GH*	*GB*	*AR*	*MR*	*AD*	*BD*	*YD*	*BG*	*YY*
Staphylococcus sp.	-	+	-	-	-	-	+	+	-
Bacillus cereus.	-	+	+	-	-		+		-
E. coli	+	+	+	+	+	+	+	+	+
Pseudomonas sp.	+	-	-	+	-	+	-	-	-
Streptococcus aureus	+	+	+	-	+	+	-	-	+

CONCLUSION

The present investigations conclude that the quality of water samples subjected to study was acceptable from physico-chemical parameters, while *E. coli*, an indicator of fecal pollution was found in all samples. The river Ganga at Brahma Kund in Haridwar was most polluted despite being a quite popular tourist place in Haridwar.

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