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Pollution Assessment of River Ganga Segment in Uttarakhand

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Abstract—*Soil erosion due to rain and wind action is a serious problem in India. Its negative impacts include reduction in soil productivity, silting of dams and reservoirs, deficits in water availability, pollution of water courses, serious damages to properties by soil-laden runoff, and desertification of natural environments. In the present study, chemical and physical parameters of the river were observed. The river Ganga segment in Uttarakhand was taken as study area from Devprayag (30.14^{0}N, 78.59^{0}E) to Balawali (29.64^{0}N, 78.1^{0}E). From the study area, a total of twelve locations were selected and water samples were taken in February and June.The classification of the locations of the samples of both the months for the utilization of water for various purposes like drinking water source without conventional treatment but after disinfection, fish culture and wild life propagation and irrigation and industrial cooling or controlled waste disposal was done for useful interpretation of which water could be used for what purposes according to desirable and permissible limits of pH, EC, TDS, free CO_2, chloride, total acidity, calcium hardness, total hardness and magnesium hardness.*

Keywords: *pH, EC, TDS, free CO_2, chloride, total acidity, calcium hardness, total hardness and magnesium hardness.*

1. INTRODUCTION

It is a lucid fact that water is essential for all forms of life. Water, due to its rapidly depleting sources and increasing demands has become a crisis commodity in today's world. India is comparatively richer in terms of natural water resources like river systems, glaciers, freshwater lakes, etc. But keeping in view the haphazard urbanization, industrialization, commercialization and lack of policy level measures towards the distribution and sustainable management of water in the country, it seems really inevitable that these existing water sources will fail to suffice our requirements in coming time leading to a critical situation. Water is a prime natural resource and it is a basic human need this cum natural asset.

The Ganga basin accounts for a little more than one-fourth (26.3%) of the country's total geographical area and is the largest river basin in India, covering the entire states like Uttarakhand, Uttar Pradesh, Bihar, Delhi, and parts of Punjab, Haryana, Himachal Pradesh, Rajasthan, Madhya Pradesh and West Bengal. The Ganga basin is bound in the north by the Himalayas and in the South by the Vindhyas. The main river stream originates in the Garhwal Himalaya (30^{0}55'N, 79^{0}7'E) under the name of the Bhagirathi. The ice-cave of Gaumukh at the snout of the Gangotri glacier, 4100 meters above sea level, is recognized as the traditional source of river Ganga. The river cuts its path through the Himalayas and flows a distance of about 205 km from Gaumukh and transverses through two districts of Uttarakhand state i.e. Uttarkashi and Tehri to reach Devprayag where another head stream, the Alaknanda, joins it to form Holy Ganga.

The river Alaknanda is a major tributary of the river Ganga at Uttarakhand that begins at the confluence of the Satopanth and BhagirathKharak glaciers in Uttarakhand. The river Alaknanda meets Dhauli Ganga at Vishnuprayag, Nadakini at Nandaprayag, Pindar Ganga at Karnaprayag, Mandakini at Rudraprayag, traveling approximately a total length of 190 km before meeting Bhagirathi at Devprayag. These five confluences are called the PanchPrayag.

After flowing through the northern-most part of Uttarakhand, the river flows through Uttar Pradesh, Bihar, Jharkhand and West Bengal, and finally drains into the Bay of Bengal. The river traverses a length of 1450 km in Uttarakhand and Uttar Pradesh while touching the boundary between UP and Bihar for a stretch of 110 km. It then flows through Bihar, more or less covering a distance of 405 km. The length of the river measured along the Bhagirathi and Hugli rivers during its course in West Bengal is about 520 km. The River Ganga has a large number of tributaries, namely, Kali, Ramganga, Yamuna, Gomti, Ghaghara, Gandak and Kosi. The River Yamuna, although a tributary of Ganga, is a river basin in itself. Its major tributaries are: Chambal, Sind, Betwa, and Ken. The main plateau tributaries of the Ganga river are Tons, Son, Damodar, and Kangsabati-Haldi.

Total Length is 2, 525 kms, length in Uttarakhand is 450 kms, length in Uttar Pradesh is 1, 000 kms, sharing length between Uttar Pradesh & Bihar is 110 kms, length in Bihar is 405 kms, length in Jharkhand is 40 kms and length in West Bengal 520 kms. Catchment area of Ganga basin is 861, 404 square km (26.4%) of India, average annual discharge is 493, 400 million cubic meter. Main tributaries are Yamuna, Ramganga, Gomti, Ghaghara, Gandak, Damodar, Kosi& Kali-East. Main sub tributaries are Chambal, Sindh, Betwa, Ken, Tons (beyond Five States), Sone &Kasia-Haldi. Major Cities located on the bank Srinagar, Rishikesh, Haridwar, Roorkee (in Uttarakhand), Bijnor, Narora, Kanauj, Kanpur, Allahabad, Varanasi, Mirzapur (in Uttar Pradesh), Patna, Bhagalpur (In Bihar) and Bahrampur, Serampore, Hawarah and Kolkata (in West Bengal).

Groundwater is believed to be comparatively cleaner and freer from pollution than surface water.Drinking water may come from surface water or Groundwater. Surface Water is found in lakes, rivers and reservoirs. Surface water is more vulnerable to contamination and requires extensive testing and treatment to assure that it is safe to drink. Groundwater and surface water are both part of the "hydrologic cycle". Water rises from the earth's surface as evaporation and falls to the earth as precipitation, in the form of snow or rain. Surface water becomes groundwater, when it infiltrates downward to the saturated zone.

About ten percent of the rural and urban populations do not have access to regular safe drinking water and much more are vulnerable. Most of them depend on unsafe water sources to fulfil their daily desires. Moreover, water shortages in cities and villages result in massive volumes of water being collected and transported over great distances by tankers and pipelines.

Water pollution is one of the undesirable effects of industrialization and urbanization. Water, the most vital resource on the Earth, has the distinctive property of dissolving and carrying in the suspension an enormous style of chemicals and therefore water can simply become contaminated. Available water resources are very restricted. As the population of the earth increases tremendously, the water demand also increases simultaneously for domestic, agricultural and industrial use. Therefore,groundwater level is going to deplete in coming days.

Water quality parameters are very important to use water for various purposes i.e. industrial, domestic etc. Water quality parameters can be divided into three categories: physical, chemical and biological water quality parameters. In the present study, only physical and chemical water quality parameters were studied by collecting water samples of flowing river.

Water can be polluted chemically in following three ways:

1. Atmospheric input, which includes the pollution from climatic change, precipitation, etc.
2. Interaction of water with soil and rock, which occurs when there is a weathering or erosion of the material and that eroded material mixed with water.
3. Anthropogenic activity, which is due to the industrial and agriculture pollution increase consumption which makes water unsuitable for drinking, industrial and agriculture purpose **(Simeonov *et al.*, 2003)**.

Global needs of water are around five billion cubic meter just for drinking purpose, agriculture is additionally one of the major consumers of water resources. The quality of ground and surface water is affected by several factors, like discharge of agriculture, domestic and industrial wastes. Improper management of water systems could cause serious problems and inconvenience. The quick and continuous development of commercial enterprises and also unregulated release of mechanical waste and metropolitan waste item have quickened the debasement of water quality in streams, lakes, tanks and estuaries. Water becomes unsuitable for human consumption or for irrigation of agricultural land as a result of such deterioration of water quality.

Keeping the above factors in view, the specific objectives of the study are:

1. To analyze physico-chemical water quality of river Ganga segment in Uttarakhand.
2. To assess the suitability of water quality for drinking, agricultural and other purposes.
3. Statistical analysis and modeling of water quality parameter.

   Only first objective is explained thoroughly in this research paper.

2. REVIEW OF LITERATURE

Liu*et al.*(2003) carried out factor analysis on the groundwater samples collected from 28 different wells in the coastal Blackfoot disease area of Yun-Lin, Taiwan.The correlation was examined among 13 hydro-chemical parameters. The two-factor model was suggested which explain the variation of 77.8% in quality of Groundwater. The factor 1 (sea water salinization) includes concentration of different parameter like electric conductivity, total dissolved solid, chloride, sodium, potassium, magnesium, sulfate etc. Maps are drawn to show the geographical distribution of the factors. These maps delineate high salinity and arsenic concentrations. It was found that land subsidence and gradual salinization of local area of sea water was due to over pumping of local Groundwater. Over pumping increases the dissolved oxygen, which oxidizes the mineral and releases arsenic by this solution of arsenic-rich iron Oxy-hydroxide and increases the concentration of arsenic in water.

Kaushik (1963) carried out a survey to analyze the water quality parameters by taking water from 100 wells located in Delhi. It was observed that total alkalinity was varied between 130 to 740 ppm and also the concentration of nitrate, sulfate and chloride were found between 23 to 457 ppm, 3.5 to 760 ppm and 12 to 1280 ppm.

Singh and Sekhon (1976) analyzed 57 water samples located near a village in Ludhiana and Hoshiarpur district of Punjab in June and September month. The water sample was analyzed for nitrate concentration and was found that 90% of the water samples have nitrate concentration less than 45 ppm. The concentration of nitrate in the good water near village varied with the depth and it was assumed that excessive use of nitrogen fertilizer was responsible for increased nitrate content. Rather than water sample soil samples were also analyzed for nitrate content. It was found that during a rainy season, nitrate concentration in water was more than non-rainy season.

Kumar (1983) performed a survey of several wells located in some parts of Uttar Pradesh for nitrate concentration. From the study, it was analyzed that the wells located in Badshapur, Mirzapur, Bangarmau, Birrdha have nitrate value more than 200 ppm. The higher value of nitrate was due to excessive use of nitrogen fertilizer.

Srivastava *et al.* (1988) conducted a study by taking the sample of Sone River and checked collected samples. Sone River was highly polluted by effluents from the Orient Paper Mills, Amelia, Madhya Pradesh, and India. Further, downstream improvement water quality was observed due to self-recovery and dilution. Between the Orient Paper Mills site and at the effluent mixing points greatest variability between the water sample was observed and maximum similarity was found between 2 and 2.1 km; 2.3 and 2.5 km; and 2.7 and 3 km downstream.

Mondal*et al.* (2005) conducted their studies on untreated industrial effluent which when discharged to the surface, will cause groundwater pollution to very large extent in the rural part of the country. The polluted groundwater poses problems to supply the water for drinking purpose. Tamil Nadu has more than 50 percent of tanneries. In the Din Digul town near Kodaganar river basin Tamil Nadu, about 80 tanneries are operating. These tanneries release untreated influenced that affect the quality of groundwater in this area. The Groundwater quality was deteriorated excessively due to overuse of chemical like NaCl in the leather industry.

3. MATERIALS ANDMETHODS

1. StudyArea

The study was carried out on river Ganga. A segment of river Ganga was selected for the study. The river originates from Gangotri bearing the name of the river as Bhagirathi and after reaching Devprayag, the name of the river becomes Ganga (Fig 3.4). The water sampleswerecollectedattwelve locationsfromDevprayag(30.14^0N, 78.59^0E) toBalawali(29.64^0N, 78.10^0E).

2. Water Sampling and Testing

Cleanplasticbottlesofoneliter capacity wereusedtocollectsamplesbygrabsamplingmethodfrom selectedlocationsateitherofbanks.Graborcatchsamplesaresingle collecteddataspecific spot atasiteoverashortperiodoftime(typically secondsorminutes).Thus, they representa “snapshot”inbothspaceandtimeofasamplingarea. Three replications of the water samples from each location were taken.Thesampleswerewrapped in insulatedWater quality testinglaboratoryoftheDepartmentofIrrigationandDrainageEngineering atGovindBallabhPantUniversity of Agricultureand Technology, Pantnagarandwereanalysedfor variousphysicochemicalparameters, namely PotentialofHydrogen (pH), Electrical Conductivity (EC), TotalDissolvedSolids(TDS), hardness, calcium, acidity, alkalinity, chloride, carbondioxide (CO_2)usingstandard methods (APHA, 1980).

2.1Physical propertiesof the samples

Taste, color andodorwere determinedonthespotwhilecollecting thesampleswhereasthe Potentialof Hydrogen(pH), ElectricalConductivity (EC), TotalDissolvedSolids(TDS)of watersamples were determinedinlaboratorydirectlywith thehelpofpHmeter, ECmeterand TDSmeter respectively.

2.1.1 Taste

Thetaste ofthe samples collected in both the months was determined bydrinking.

2.1.2Color

Theobservation ofthe color ofthe samples collected in both the months was done visually.

2.1.3 Odor

Theodor of the samples collected in both the months was interpreted by inhaling.

2.1.4Totaldissolved solids(TDS)

Total dissolved solids is a measure of the combined content of all inorganic and organic substances contained in a liquid in molecular, ionized or micro-granular (colloidal sol) suspended form. For estimating Total dissolved solids, 100mlofthesamplewastaken.ThedigitalTDStesterwasusedandb eforedipping thetestersensorinthevesselcontainingthesample, itwasensuredthatthe readingonthescale is zero. Oncethe reading of thetestergot stabilized, itwas noted down.

2.1.5Electrical conductivity(EC)

Electrical conductivity is the reciprocal of electrical resistivity, and measures a material's ability to conduct an electric current. For estimating the electrical conductivity, sampleof100mlwastaken.ThedigitalECtesterwasusedandbefore dippingthe testersensorinthevesselcontaining thesample, itwasensuredthatthereading onthescaleis zero. Oncethereadingofthe testergot stabilized, itwas noted down.

2.1.6Potentialof hydrogen ion (pH)

Potential of hydrogen is a numeric scale used to specify the acidity or basicity of an aqueous solution. For estimating the pH, 100mlsamplewastaken.ThedigitalpHtesterwasusedandbeforedipping the testersensorinthevesselcontaining thesample, itwasensuredthatthereading onthescaleis zero. Oncethereadingofthe testergot stabilized, itwas noted down.

2.2Chemicalproperties

The chemicalanalysisofcollectedsampleswereperformedtoestimatetotalalkalinity, total acidity, total hardness, calcium, magnesium, calcium hardness, magnesium hardness, chloride, freecarbondioxide(CO_2).The parametersweredeterminedas perstandardmethods ofwateranalysisspecifiedby AmericanPublicHealthAssociation(APHA), AmericanWater Work Association(AWWA) and Water PollutionControlFederation (WPCF) asdescribed below.

2.2.1Totalacidity(TAc)

Total acidity is a measure of the amount of acid present in a solution. Todeterminetheconcentrationoftotalacidity, a sampleof 100 mlwastaken and 3 drops of methyl orange indicatorwereaddedtoit.Titrationwasdonewith 0.05 normality sodium hydroxide (NaOH) untilthecolor changedtofaint pink at the end pointandfurther titration was continuedafter adding 3dropsof phenolphthaleinindicatortothesame sampleuntilcontentturned pink. If samplechangedcolortoyellowafteradditionof methylorange indicator, 3 dropsofphenolphthaleinindicatorwere addedtoitandtitrated against 0.05 normality NaOH untilthecontentturnedpink.Totalaciditywas determined usingthe followingrelationships,

Total acidity as $CaCO_3$, ppm = A × B × 50 × 1000 / C ... (3.1)

Where, A =Volume of titrant (NaOH)used, ml

B =Normalityof titrant

C = Volume of sample used, ml

2.2.2Totalalkalinity(TAl)

Total alkalinity is the equivalent sum of the bases that are titratable with strong acid (Stumm and Morgan, 1981). Tofindouttheconcentrationoftotalalkalinity, a 100ml samplewastaken and2dropsof phenolphthalein indicator were added to it.If the color changedcolortopink, titrationwasdonewith0.1 normality hydrochloric acid (HCl) untilthecolordisappearedattheendpoint.Then3dropsofmethylorangeindicatorwereadded tothesamesampleandtitrationwascontinueduntiltheyellowcolor changedtopinkattheend point.If sampledid not change colorafter additionof phenolphthalein indicator, 3dropsof methylorangeindicatorwereaddedtoitandtitratedwith0.1 normalityHCluntiltheyellow colorchangedtopinkattheendpoint. Total alkalinitywas estimatedas,

Total alkalinity as $CaCO_3$, ppm = A × B × 50 × 1000 / C (3.2)

Where, A =Volumeof titrant (HCl) used, ml

B = Normality of titrant

C = Volume of sample used, ml

2.2.3Totalhardness (TH)

Total hardness is hardness (mineral content) that cannot be removed by boiling. Todeterminetheconcentrationof totalhardness, a 10mlof water sample wastakenanddiluted to50mlusing distilledwater, 1mlofbuffersolutionand0.2gofEriochromeBlackTindicatorwereaddedto it.Thecontentwastitratedagainst 0.01 normality ethylene diamine tetra acetic acid (EDTA) solutionuntilthewineredcolorchangedtoblueat the end point. Thetotal hardnesswasfoundas,

Total hardness as $CaCO_3$, ppm = A × 1000 / C (3.3)

Where A = Volume of titrant (EDTA) used, ml

C = Volume of sample used, ml

2.2.4Calcium hardness (CaH)

Calcium hardness is presence of calcium ions in water, from dissolved carbonates and bicarbonates. To determinetheconcentration ofcalcium, a10mlof water samplewas taken anddilutedto50ml, 2mlof 0.01 normality NaOH solutionand0.2gofMurexideindicatorwereaddedtothesampleandthecontentwastitrated againstEDTAsolutionuntilthepinkcolorchangedtopurple.Theconcentrationofcalciumwas found as,

Calcium, ppm = A × 400.8/C (3.4)

Calciumhardness, ppm=Calcium, ppm×2.497 (3.5)

Where A = Volume of titrant (EDTA) used, ml

C = Volume of sample used, ml

2.2.5Magnesium (MgH)

Magnesium hardness is presence of calcium ions in water, from dissolved carbonates and bicarbonates. Magnesiumconcentration wasdetermined usingformula,

Magnesium hardness, ppm = Total hardness - Calcium hardness(3.6)

Magnesium, ppm=Magnesiumhardness × 0.244 (3.7)

2.2.6Chloride (Cl)

Chloride ion is the anion widely distributed in nature as salts of sodium (NaCl), potassium (KCl), and calcium ($CaCl_2$).

Todeterminetheconcentrationofchloridecontent, a 50mlofsamplewastaken and 2mlofpotassiumchromatesolution wasaddedtoit.Thenthecontentwastitratedagainst0.02 normalitysilvernitrite ($AgNO_3$) untilthepersistentred tinge appeared. Thechloride concentration was obtained as follows,

Chloride, ppm = A × B × 35.5 × 1000 / C (3.8)

Where, A = Volume of titrant ($AgNO_3$) used, ml

B = Normality of titrant

C = Volume of sample used, ml

2.2.6Free carbondioxide (FCO_2)

Free carbon dioxide is carbon dioxide that exists in the environment. To determine the free carbon dioxide, a 100ml sample wastitratedagainst0.05 normalityNaOHsolutionusingphenolphthaleinasan indicator.Theendpointwasmarkedby appearanceofpinkcoloratapHof8.3.Thequantity of free$CO_2$was calculatedusingthe formula,

FreeCO_2, ppm =A × N × 44 × 1000 / C (3.9)

Where, A =Volumeoftitrant (NaOH) used, ml

B = Normality of titrant

C =Volumeof sample used, ml

4. RESULT

1. Taste

The taste of the samples of both the months was found to be agreeable.

2. Odor

The odor of the samples of both the months was found to be unobjectionable.

3. Color

The color of the sampled water was found to be clear in February, whereas the color of the sampled water was found to be brown in June.

4. Potential of hydrogen (pH)

The pH of the samples varied from 7.4 to 7.6 in February. The pH of the samples varied from 5.9 to 6.4 in June.

5. Electrical conductivity (EC)

The EC of the samples varied from 102 µS/cm to 158 µS/cm in February. The EC of the samples varied from 130 µS/cm to 180 µS/cm in June.

6. Total dissolved solids (TDS)

The TDS of the samples varied from 61 ppm to 95 ppm in February. The TDS of the samples varied from 64 ppm to 89 ppm in June.

7. Total hardness (TH)

The total hardness of the samples varied from 67 ppm to 83 ppm in February. The total hardness of the samples varied from 130 ppm to 210 ppm.

8. Calcium hardness (CaH)

The calcium hardness of the samples varied from 38.98 ppm to 45 ppm in February.The calcium hardness of the samples varied from 60.05 ppm to 160.13 ppm in June.

9. Magnesium Hardness (MgH)

The magnesium hardness of the samples varied from 28.02 ppm to 39 ppm in February. The magnesium hardness of the samples varied from -20.13 ppm to 139.95 ppm in June.

10. Total Acidity (TAc)

The total acidity of the samples varied from 13 ppm to 40 ppm in February. The total acidity of the samples varied from 25 ppm to 87.5 ppm in June.

11. Total Alkalinity (TAl)

The total alkalinity of the samples varied from 59 ppm to 74 ppm in February. The total alkalinity of the samples varied from 85 ppm to 125 ppm in June.

12. Chloride (Cl)

The chloride content of the samples varied from 5 ppm to 5.6 ppm in February.The chloride content of the samples varied from 14.2 ppm to 35.5 ppm in June.

13. Free carbon dioxide (FCO_2)

The free carbon dioxide content of the samples varied from 2.8 ppm to 4.2 ppm in February.

The free carbon dioxide content of samples varied from 6.6 ppm to 61.6 ppm in June.

5. CONCLUSIONS

1) The taste of the water taken in samples of both the months was agreeable.The odor of the water samples of both the months was unobjectionable.The water samples were clear in February whereas the samples were brown colored in June.
2) The pH of the samples was found to be within the desirable limit in February whereas it was beyond the

desirable limit in June. EC and TDS were within the desirable limit in both the months.

3) The total hardness was found to be within the desirable limit in February whereas it was within the desirable limit except for Ghuret which was just at the desirable limit and for Veerbhadra which was above the desirable limit but within the permissible limit in June.The calcium hardnesswas found to be within the desirable limit in February whereas it was within the desirable limit for Ghuret and for all others, it was within the permissible limit in June. The magnesium hardnessof water sample of Bhagirathi was found to be within the desirable limit and all other places within the permissible limit in February whereas Trivenighat, Rampur RaighatiAhat and Balawali were within the desirable limit and all the places within the permissible limit except for Kauriyala where magnesium hardness was negative in June which means that instead of the magnesium ionwhich is divalent, the presence of hardness was due to monovalent ions like sodium, potassium, etc.

4) The total alkalinityin both the months was found to be within the desirable limit.The chloridein both the months was within permissible limit.The free carbon dioxidewas found to be within the permissible limit in February whereas except for Trivenighat, all other locations were within the permissible limit in June.

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