1. INTRODUCTION

1.1 Overview

Ganga is not an ordinary river. It is a life-line, a symbol of purity and virtue for countless people of India. Ganga is a representative of all other rivers in India. Millions of Ganga devotees and lovers still throng to the river just to have a holy dip, Aachman (Mouthful with holy water) and absolve themselves of sins. We Indians are raised to consider Ganga as a goddess, as sacred. We tell our children and grandchildren the stories of how she came down to Earth through a lock of Lord Shiva's hair. The Ganga temples, countless rituals associated with Ganga and our belief that Ganga is a cleanser par excellence prove that Ganga has a status of a deity. Hundreds of verses have been used to extol her glory and greatness. Lord Krishna, Lord Rama, Lord Siva, Lord Vishnu including great saints like Sri Swami Sivananda, Sri Ramakrishna and others have all glorified her.

River Ganga has its source at Gaumukhi in Himalaya hills. This place is 18 miles away from Gangotri. During its downward flow it passed through Uttarkashi, Rishikesh, Haridwar, Saharanpur, Narora, Kanpur, Allahabad, Varanasi, Kolkata and finally merges in Bay of Bengal (Knows as Ganga Sagar). The Ganga (2525 km) carries off the drainage vast basin bounded by the snow peaks of the Himalaya in the north and the peninsular uplands and the Vindya range on the south.

The Ganga has by far the largest river basin in India, draining as much as 861404 km^2 within our country, covering more than a quarter (26.2 percent) of India's geographical areas.

Having a large surface water and ground water resource with an annual flow of 468.7 billion cubic meters (25.2 percent of India's total water resources) it is more important that the level of pollution is kept at minimum possible within the Gangetic basin.

The Ganga rises in the Garhwal Himalaya ($30^0$55'N, $79^0$7'E) under the name of Bhagirathi. The ice cave of Gaumukhi at the snout of the Gangotri glacier, some 4100 metres above sea level, is recognized as the traditional source of ganga. The river cuts its path through the Himalaya till another head stream, the Alaknanda joins at Devaprayag. It is the blow this confluence that the united steam is generally known as the Ganga River.

After a run of the some 250 km, the Ganga pierces through the Himalaya near Rishikesh and turns southwest wards for another 30 km so to finally debauch on to the vast in to Gangetic plain at Haridwar. Thousands of pliligrims take dip in the holy water at Rishikesh, Haridwar, Garmukteshwar, Kannauj, Allahabad, Mirzapur and Varansi almost every day. In fact, all along the course of the Ganga, from its source at Gaumukh to its mouth at larger island, it is a common practice for Indians to take dips the holly waters of the Ganga, especially at places of pilgrimage.

Hence the quality of water is essential, therefore it becomes imperative that strict monitoring of the quality water along different reaches of the river is maintained and adequate measures are taken to keep the Ganga free from pollution particularly at the bathing Ghats, places of pilgrimage and at abstraction points on its course, as far as practicable.

The Ganga water is widely used for domestic and industrial purpose in towns and villages located on its course for which it is also equally necessary to continuously watch the level of possible pollution of the different seasons.

So that adequate measures can be taken to keep the concentration of various pollutants in water within permissible limits of toxicity. The other wide use of the Ganga water is in the field of irrigation. A large quantity of water is taken out by the upper Gangatic canal network off the head works located at Haridwar for irrigation a major portion Ganga-Yamuna doab in Uttar Pradesh, during the flow to only 15 billion cm^3 per annum at Balwala. As it flows further downstream, a few minor tributeries join adding to the volume of water, which is now loaded with enough sediment giving a hue of yellow ochre to the Ganga water.

Table 1.1: Location of different major cities from origin of Ganga river.

S. No.	Stations	Distance from source (km)	Elevation from mean face level(m)
1	Rishikesh	250	350
2	Garhmukteshwar	440	200
3	Fatehgarh	670	145
4	Kanpur	800	138
5	Allahabad	1050	95
6	Mirzapur	1170	90
7	Varansi	1295	80
8	Buxar	1430	60
9	Patna	1600	50

Pollution from industrial and urban wastes has no doubt, serious detritus effects in water in the Gangetic basin but at same time the water run-off from rural settlements, cattle pans, agriculture farms etc. in the river is likely to be toxic enough to pollute the prevailing water bodies and drainage system.

The heavy silt load brought down by the run-off also affects the water quality and causes navigational problems and other environmental hazardous in Ganga water.

As there is strong relationship between every aspect of human activities like farming, urbanization, industrialization, river basin development etc and the nature and degree of water pollution, it is urgently necessary to adopt a long range view of the trends of development in all areas of human and economic activities within Ganga basin over a period of time in order to estimate the likely impact of these activities on pollution load and the quality of water in drainage channels. In order to fulfill this objective, it is necessary to analyze inter-relationships between various aspects of human activities, development projects, steams flows, pollution loads and water quality during a given span of time under certain basic assumption of economic growth and development.

The Ganga is the largest and the most important river of India and no wonder that it served as the cradle of the Indian civilization. The problem of pollution of the Ganga water due to discharge of industrial effluents is getting more and more serious. Survey of water channel of the river Ganga at Kanpur has revealed that the villages, towns and cities which fall in the way of the river have familiar practice of dispersing waste water through drains which merge with wide and deep channels terminating at Tributaries Rivers. These rivers have downward stream of Ganga and finally merge with it near Kanpur, dumping their toxic wastes and cause a lot of pollution. In addition to persistent disposal of the domestic waste in the river Ganga, large numbers of industrial units are situated at Jajmau, Kanpur city, U.P, India.

These industrial units of Jajmau in Kanpur release their toxic effluent in the Ganga River directly or indirectly.

This has caused severe water pollution in the river Ganga to the extent that it’s water is no more potable and is passing severe threat to the survival of aquatic flora and Fauna.

The biodegradable pollutants are gradually depleting the dissolved oxygen of water, which is prerequisite for the sustenance of aquatic life, thus enhancing its BOD beyond the tolerance limit. The non-biodegradable pollutants are undergoing bio-magnification at higher trophic levels and causing mortality in fishes and other animals. What would be happen when the water pollutants gathered in the river water reach the threshold levels of toxicity at which phytoplankton (which account for 60% of our photosynthetic oxygen) ceases to function? Also when dissolved oxygen would be depleted by biological oxygen demand. Then life of plants and animals would disappear because of death or migration. Bacterial decomposition shifts from aerobic (oxygen requiring) to an anaerobic (not oxygen requiring) conditions.

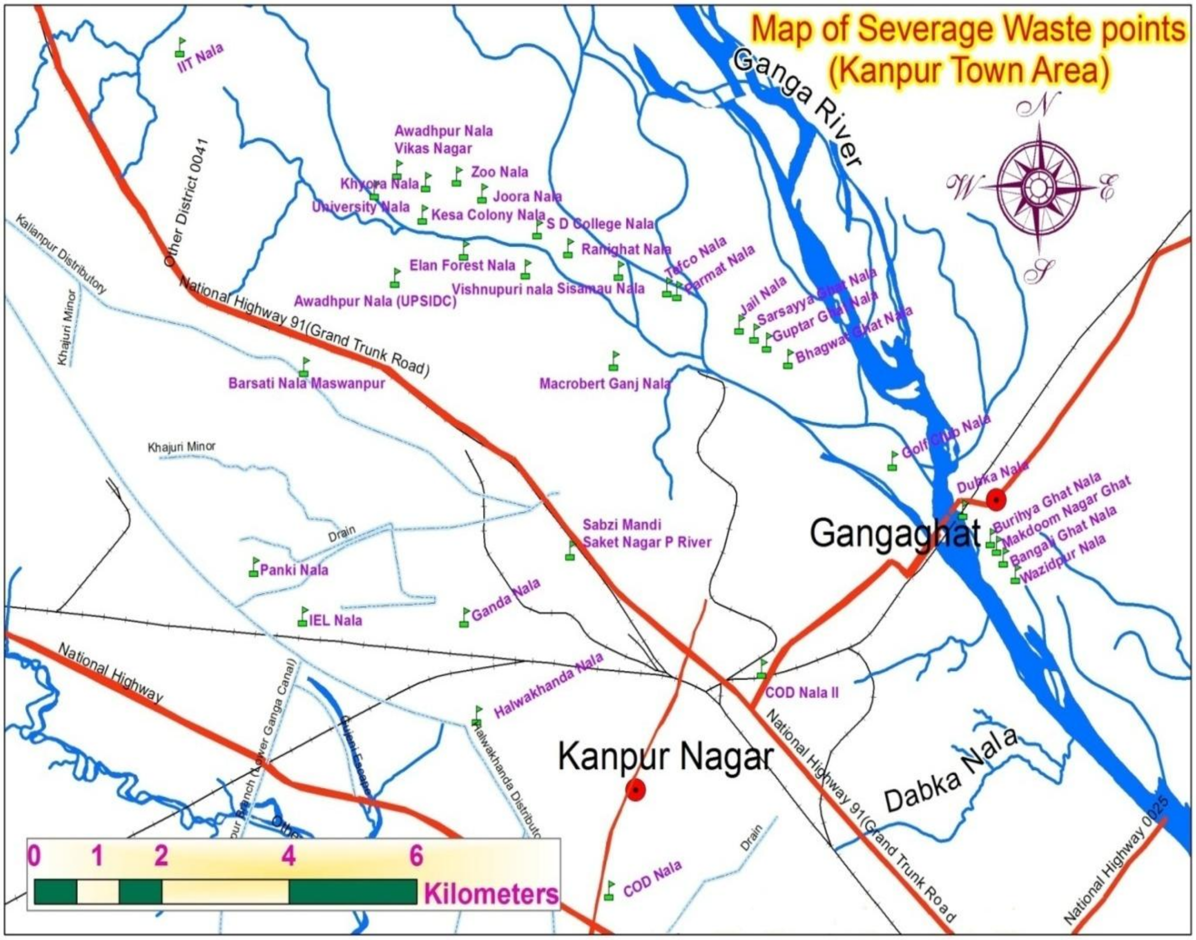

Figure 1.1: Map of Ganga River showing locations of different sources of polluting effluents.

The impact of the River Ganga (The Ganges) is widely felt in Indian community life. The Ganga has shaped the cultural, spiritual and economic life of the Indian people. The river is subjected to uses and misuses, such as use for domestic and industrial water supplies. The disposal of sewage and industrial wastes leads to severe river water pollution. Naturally the pollution levels of the Ganga River have caused serious concern and attracted wide attention.

The pollution problems of the River have caused serious concern and various corrective measures have been initiated to improve the water quality of the river.

Critical assessment of the system is needed to examine the efficacy of any measures taken and new suggestions as to how to improve and implement these economically. These considerations led the Central Pollution Control Board of India to initiate a regular water-quality monitoring program in the Ganga basin in 1979. Systematic monitoring of the water quality will help to assess the pollution load of the river water and the effectiveness of the different measures taken to control pollution. The data will serve to try to preserve the age old belief of the holiness of the river and the purity of Ganga river water.

About 70 percent of the water flow is during the period of the south-west monsoon (June to September) and during the summer period (March to May) the water is very low. There is heavy siltation at the mouth of the Bhagirathi and the river is tidal for its entire length from Swarupganj to the mouth. The speed and direction of the water flow in the estuarine streams and creeks are in continual flux, and the movement of the pollutants, either suspended or dissolved, is greatly dependent on the diurnal rhythm of the flow and ebb tides. The water pollution management is therefore, extensively conditioned by the tidal forces.

In global scenario the Kanpur is the top and famous for tannery industries. The Kanpur city is also known for their pollution in the world. The main reason of the pollution in Kanpur is due to the Tanneries. Only about 20% of the chemicals used in the tanning process are absorbed by leather while rests of these are released as wastes, which are absorbed by bioaccumulation process in cultivated crops. The wastes from the tannery consist of tanned and untended solids, waste effluents and waste gases. In Kanpur, city of Uttar Pradesh (India) a large number of leather units are located at Jajmau area, right on the bank of river Ganga.

These units, which use many toxic chemicals, are the single largest contributor to the pollution of the surface as well as ground water of Jajmau area in Kanpur.

Environmental pollution is one of the major problems of the world which increases day by day due to urbanization and industrialization. Over the last few decades, large scale usage of chemicals in various human activities has grown very fast, particularly in a country like India. Ground water is of great importance for potable water supply and also serves for the agricultural irrigation and industrial production. Ground water resources are experiencing an increasing threat of pollution coming from urbanization, industrial development and agricultural activities. The global water pollution due to the increase in number of industries is a serious problem faced by the modern world. Release of the effluents in the receiving water is the major reason for water pollution. These pollutants find their way to aquatic ecosystem such as rivers, ponds and lakes which pose a risk to the health of human and ecosystem. Almost all industries discharge water containing wastes in one stage or another during their manufacturing process. Industrial waste is not the same in every case.

As a result the presence of pollutants in water alters different physico-chemical parameters from their normal prescribed levels. A negative impact on water quality includes increase in turbidity, colour, and nutrient load, addition of toxic and persistent compounds. The diversity in physical, chemical and biological characteristics of tannery effluent is so much that each effluent habitat requires a separate study.

Industrial effluents from leather tanneries discharged higher amount of metal especially chromium. These effluents released in river or canal, as well as dumped into ground water and lead to contamination of chromium due to accumulation.

The toxicity of chromium through drinking water is the major problem for human health. Tanneries have been found to discharge not only Cr which is an inherent product of the tanning process but also significant amounts of Zn, Mn, Cu and Pb have been observed at the main waste disposal metals exceeding the toxic range in soil.

The sludge derived from the treatment of tannery effluent varies in composition but usually contains water (65-98%), lime, Cr, hydrate oxide, residual sulphides and organic matter (proteins, hair and grease). The Common mineral elements such as Al, Fe, Ca, Na, Mg, K and Si are present in significant quantities in sludge and may also contain trace elements and heavy metals such as Cr, Cd, Pb, Hg, As, Cu, Ni, Zn, B, Se, Mo as well as N and P in both organic and inorganic forms. Eventually the effluents and sludge from these tanneries are discharging onto land and into water bodies. The dissolved and suspended particles of the effluent would affect the quality of ground water, in addition to reduced clarity. There is also a great danger to man and livestock particularly from the high Cr content and it has been found to be toxic to humans at levels as low as 0.1 mg/L. Hence, need to monitor the heavy metal pollutant levels of these areas.

The Ganga river in Jajmau area at Kanpur city is valuable source of irrigation and fishing, so in order to find current status of pollutants discharged from the various tanneries, chemical criteria provide significant information about the present status of contaminant concentration on Ganga river water and their impact on blood chromium content with special reference to human health.

Presently the Sewage Treatment Plant (STP) installed to treat sewage from Kanpur city is not working to its full capacity. Also river flows across the city of Kanpur without receiving fresh water from any tributary till it is joined by Kali and Ramganga at Kannauj.

At Kanpur, a local river called Pandu meets Ganga river. The tannery industry mushrooming in North India has converted the Ganga river into a dumping ground. Pollution becomes acute when tanneries are concentrated in clusters in small area like Kanpur, U.P, India. The tanning industry is known to be very polluting especially through effluents high in organic and inorganic dissolved and suspended solids content accompanied by propensities for high oxygen demand and containing potentially toxic metal salt residues.

In 1996, the Supreme Court of India ordered the closure of all tanneries that had not set up pollution control system. Using government subsidies, the tanneries have built numerous Common Effluent Treatment Plants (CETPs) to treat the toxic waste water discharged from tanneries. The treatment of this type of wastewater is very complex mainly because of the variety of chemical products added in different concentrations. The effects of various industrial effluents, sludge materials and metal elements on seed germination, growth and yield of crop plants have captivated the attention of many workers.

The present study was designed to assess the effect of tannery effluent on physico-chemical parameters like pH, temperature, Conductivity, TH, TA, TDS, DO, COD, BOD and Cr metal of Ganga river water by addition of percent treated tannery effluent in laboratory condition and its seasonal variation. The water quality of Ganga river can be estimated after addition of percent tannery effluents in laboratory condition to predict the future physico-chemical quality status of river water.

The Ganga River at Kanpur city U.P, India, is valuable source of irrigation, fishing and house work, so in order to find current status of pollutants discharged from the various tanneries, the study was conducted to analyze the impact of tannery effluent on Ganga river water quality seasonally.

As chemical analysis of water provide significant information about the present status of pollution river water with special reference to environmental health. This will prove the current suitability and future physico-chemical status of Ganga river water if it is discharged effluent by industries in current manner and current rate.

India is the third largest producer of leather in the world having about 3000 tanneries with annual processing capacity of 0.7 million tones of hides and skin. The tannery industry effluent is highly toxic to flora and fauna due to the presence of excess amount of dissolved solids, chlorides, sulphides, chromium with a very high BOD, COD and conductivity in the effluent. Chromium trivalent, Cr (III) and hexavalent, Cr (VI) present in effluent is one of the most toxic pollutants. Cr (VI) is more toxic and carcinogen than the Cr (III) due to its highly solubility in water, rapid permeability through biological membrane, and subsequent interaction with intracellular proteins and nucleic acid.

The various parameters used for water quality characterization and their significance standards have been prescribed in Table 1.2

Table 1.2 Various parameters used for water quality characterization and their significance standards.

Parameters	**Significance**	**Standards**
pH	pH indicates the acidity or alkalinity of water	6.0 – 9.0 or depends upon source
Dissolved Oxygen	Source of O_2 for respiration of aquatic life.	4-6 mgL^{-1}
Total suspended solids	Increases heat absorption in water bodies	Vary with location change
Total Dissolved solids	Indicate total inorganic and mineral compounds	500 mgL^{-1} for different vital activities
BOD	Amount of O_2 required for Biological oxidation by microbes in any unit volume of water proportional to the amount of organic wastes present in water.	< 3 mgL^{-1}
COD	Indicates organic matter concentration in water, oxidizable by chemical reaction	0.5 mgL^{-1} for purity

In present study Various physico-chemical parameters like pH, temperature, total alkanity, total hardness, DO, TDS, BOD, COD and heavy metal like chromium of Ganga river water samples at Kanpur in different season has been analyzed. Modulatory effect of tannery effluents on physico-chemical parameters at different concentrations has also studied. The observed values of various physico-chemical parameters of water samples will be comparing with standard value of WHO. The WHO standards for drinking water are given below in the table 1.3.

Table.1.3 WHO standards for drinking water.

S. No.	Parameters	Units	Drinking water WHO Standard	
			HDL	**MPL**
1	Temperature	˚C	---	---
2	Turbidity	NTU	5	10
3	pH value	-	6.5 to 8.5	No relaxation
4	Total hardness (as CaCO3)	mg/L	300	600
5	Iron	mg/L	0.3	1.0
6	Chlorides	mg/L	250	1000
7	Dissolved Solids	mg/L	500	2000
8	Calcium	mg/L	75	200
9	Sulphate	mg/L	200	400
10	Nitrate	mg/L	50	No relaxation
11	Fluoride	mg/L	1.0	1.5
12	Total Alkalinity	mg/L	200	600
13	Magnesium	mg/L	30	150
14	Oxygen Observed from $KMnO_4$ at 37°C in 3 hrs.	mg/L	3.0	No relaxation
15	Suspended Solids	mg/L	20	150
16	Dissolved Oxygen	mg/L	2	6

In order to compare the results obtained with the Indian standard Parameters, the Indian Standards specification are given in Table1.4

Table 1.4 Indian standard specifications for drinking water IS:10500.

S. No.	Parameters	Limits	
		Requirement (Desirable limit)	**Permissible limit in absence of alternate source**
1	Temperature(^{0}C)	-	-
2	pH	6.5 – 8.5	No relaxation
3	EC(μScm^{-1})	500	1000
4	TDS (mgL^{-1})	500	2000
5	Total Hardness as $CaCO_3$ (mgL^{-1})	300	600
6	Total alkalinity (mgL^{-1})	200	600
7	Calcium (mgL^{-1})	75	200
8	Magnesium (mgL^{-1})	30	100
9	DO (mgL^{-1})	3	10
10	Chloride (mgL^{-1})	250	1000
11	Chromium as Cr^{6+} (mgL^{-1})	0.05	No relaxation

Table.1.5 General Standards for discharge of environmental pollutants (Effluents)

S. No.	Parameters	Standards			
		Inland Surface Water	**Public Sewers**	**Land of irrigation**	**Marine/Costal Areas**
1	Suspended solids, mg/L, max.	100	600	200	**a.** For process waste water 100 **b.** For cooling water effluent 10 percent above total suspended mater of influent
2	pH value	5.5 - 9.0	5.5 - 9.0	5.5 - 9.0	5.5 - 9.0
3	Temperature	Shall not exceed 5˚C above the receiving water temperature	-	-	Shall not exceed 5˚C above the receiving water Temperature
4	Oil and grease, mg/L, max.	10	20	10	20
5	Biochemical oxygen demand (3 days at 27˚C), mg/L, max	30	350	100	100

6	Chemical oxygen demand, mg/L, max	250	-	-	250
7	Arsenic mg/L, max	0.2	0.2	0.2	0.2
8	Total chromium (Cr), mg/L, max	2.0	2.0	-	2.0
9	Bio-assay test	90 % survival of fish after 96 hours in 100 % effluent	90 % survival of fish after 96 hours in 100 % effluent	90 % survival of fish after 96 hours in 100 % effluent	90 % survival of fish after 96 hours in 100 % effluent

Industrial effluents with such higher values than the permissible limits if discharged into inland surface water will lead to pollution of the water bodies. Health impacts of various contaminants are given in table 1.6.

Table 1.6: Health impact of various contaminants

Contaminants/Pollutants	**Health Impact**
TDS	Gastro intestinal irritation
TSS	Gastro intestinal infection
Hardness	Decomposition of calcium in nerves, formation of stones, stomach disorder
Sulphate	Gastro intestinal irritation
Nitrate	Methaemoglobinemia
Fluoride	Dental and skeletal fluorosis
BOD and COD	Excessive bacterial production
Copper	Damage of liver
Nickel	Lung cancer, cancer of nasal sinus
Chromium	Liver, kidney, and respiratory organs with hemorrhagic effect, dermatitis and ulceration of the skin
Cadmium	High blood pressure, kidney damage and destruction of RBCs.
Arsenic	Skin and lung carcinogen
Mercury	Kidney, neurological and renal disturbances

1.2 Aims and Objectives

The Ganga river in Kanpur, U.P, India, is valuable source of irrigation, fishing and house work, so in order to find current status of pollutants discharged from the various industries mainly tanneries, the present study is aimed to assess the effect of tannery effluents on physico-chemical quality of Ganga river water and its seasonal variation.

The present study entitled “Modulatory Effect of Tannery Effluents on Physico-Chemical Quality of Ganga River Water and Its Seasonal Variation” is planned to ascertain the extent of water pollution caused due to addition of tannery waste water in to Ganga river during the course of travel from upstream (Bithoor ghat) to downstream (Siddhanath ghat) through the city.

This study imbibes following objectives.

1. To study the physico-chemical quality of the Ganga river water at Kanpur:

   The study of physico-chemical analysis of river water provides significant information about the present status of river water pollution with special reference to environmental health.

   The study of physico-chemical quality of the Ganga river water will also provide information about pollution load imparted by the city in to the Ganga river during the course of travel from upstream (Bithoor ghat) to downstream (Siddhanath ghat) through the city.

2. To compare the seasonal variation in the physico-chemical quality of the Ganga river water:

The seasonal variation studies of physisco-chemical parameters will provides exact impact of industrial effluent on health of Ganga river, as river water quantity and water current are varied in different seasons.

3. To study the modulatory effect of tannery effluents at different concentrations on physico-chemical quality of Ganga river water in different seasons:

   It is difficult to assess the exact impact of tannery effluent on physico-chemical quality in natural conditions as there are many sources of pollution. Hence, effect of tannery effluent on physico-chemical qualities like temperature, pH, Electrical conductivity, TH, TA, TDS, DO, COD, BOD and Cr metal of Ganga river water was assessed by percent addition of tannery effluent in laboratory condition. The water quality assessment of Ganga river after percent addition of tannery effluents in laboratory condition will predict the future physico-chemical quality status of river water.

4. To suggest the corrective measures for restoring the quality of water in Ganga river:

   Based on data observed, the study suggests appropriate preventive and remedial measures. Further, the result of physicochemical characteristics of tannery effluent obtained may encourage researcher to develop new methods for treatment of waste water released by tanneries.

5. To create increasing awareness among the people to maintain the Ganga river water at its highest quality and purity levels:

   The findings of the study will be communicated in various reputed journals, which may create awareness about current status of Ganga river pollution.