II REVIEW OF LITERATURE

The limnology suggests complete knowledge of fresh water area including its Physico chemical and biological aspects (Knight 1970). While pollution is a change in the environment, which become gradually worse (Prakash and Rawat 1979) and acting as the important limiting factor (Odum 1971).

On Indian surface water are concerned scientists turned to limnology at very late i.e. 19th century. In India, hydrobiological conditions of lakes and pond were initially pioneered by Prasad (1916) Prythi (1933). The studies covered the different aspects of lotic and lentic water impoundments with ecological variation, water quality controls fisheries problem and sewage water utilization. It was followed by Ganapati and Chacko (1951), Ganapati (1951), Ganapati and Sreenivasan (1968, 1970, 1974, 1976) on the south Indian almost all the fresh water reservoirs.

Our improved social development faces a unique crisis in the form of environmental pollution. Various sources such as industrialization urbanization are polluting it. Addition of domestic and human wastes is functioning toxically for the growth of flora and fauna of the waterways.

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In India, several workers from different parts of the country extensively carried out limnological work of river Ganga, Yamuna, Godavari and Damodar. Following are the review of limnological work of some Indian Rivers.

**River Ganga**: The river covers a distance of approximately 1550 km in the state of Uttar Pradesh passing through the districts of Garhwal, Shahaapur, Bulandshahar, Aligarh, Farukhabad, Kanpur, Unnao, Fatehpur, Rae Bareli, Pratapgarh, Allahabad, Mirzapur, Varanasi, Ghazipur and Ballia. Incidentally it was in Uttar Pradesh at Varanasi and Kanpur the former a famous pilgrim centre and the later being the industrial capital of the state of Uttar Pradesh that studies of physico-chemical characteristics of the river were initiated.

Lakshminarayana (1965) published a series of papers reporting the results of studies carried out at Varanasi during the period between March 1957 and March 1958. It was observed by him that values of the most of the parameters decreased during the rainy season while no marked variation was observed during the winters & summer.

In the same year Chakraborty et al (1965) from Kanpur reported the water quality of Ganaga at J.K. Rayon’s water intake point and Golaghat and Bhairoghat pumping stations situated at the upstream of the river. It was concluded that the water quality gradually deteriorated as it passes from Bhairoghat pumping station received wastewaters from the number of sewage drains. A year later Saxena et al (1966) who also studied the river at Kanpur concluded that the tanneries significantly increased the pollution load of the
river as they discharge huge amounts of effluents containing organic wastes and heavy metals. It was further reported that forty-five tanneries, ten textile mills and several other industrial units discharged 37.15 million gallon per day of waste water generating BOD load of approximately 61630 kg/day. In the another publication in the same year Ray and David (1966) noted that the 35 Km. stretch of the river Ganga at Kanpur was grossly polluted up to Jajmau and regeneration capacity of river water had failed to keep pace with the input of the pollutants.

After decade another paper on the physico-chemical characteristics of river Ganga at bathing ghats and sewage outfalls in Varanasi city was published by Agarwal et al (1976 a.). The conducted studies on the distribution of total solids, Free and albuminoid ammonia, Nitrite and nitrate- Nitrogen, Chlorides, DO, and BOD of the river water at bathing ghats and sewage discharge points and pointed out that in spite of the discharge of raw sewage the water quality at bathing ghats was fairly clean.

Subsequently Agarwal et al (1976 b.) studied the bacteriological pollution of the river water and concluded that addition of untreated waste and sewage was responsible for the presence of pathogenic organisms posing a threat to the residents of the city. Pandey and Pandey (1980) who analyzed the river water of Kanpur for fifteen physico-chemical parameters at nine sampling sites concluded that the river received huge discharge of effluents which had degraded the water quality severely during winter and summer seasons beyond the capacity of assimilation of the river.

The decade beginning with 1980 coincided with the spurt in the studies on physico-chemical characteristics of the river at several places. The first such
paper was authored by Dutt and Chaudhari (1980) who reported that the river water and sediments were also shown to contain detectable amounts of mercury at Kanpur through the concentrations were not beyond the permissible limits. One year later Handa et al (1981) reported that the water of the right bank of the Ganga at Kanpur near old bridge had high concentrations of Fe and Mn as compared to that of the left bank.

At the 1980 session of Indian Science Congress at Varanasi, scientist expressed concern at the growing pollution in the river Ganga in the presence of the Prime Minister Mrs. Indira Gandhi who inaugurated the session. At her instance, Dr. M.S. Swami Nathan, the then member, Planning Commission asked the Central Board for Prevention and control of water pollution, New Delhi to conduct studies on the state of the river Ganga. In collaboration with the state pollution control boards of Uttar Pradesh, Bihar and West Bengal and centre for study of Man and environment Calcutta, studies were conducted on the sources of pollution including all human activities, land use pattern and water quality of the river at selected sites during 1981-1982 and report entitled “Basin, sub – basin inversely of water pollution in the Ganaga basin part II” was published in 1984. According to this report sewage of 27 class I sites and towns and effluents from 137 major industries were the main source of the pollution of the river. In the addition cremation of the dead human bodies and dumping of carcasses aggravated the pollution of the river. Later it was decided to entrust the universities and institutions situated on the course of Ganga to conduct integrated studies of the river. For this purpose, the upper Ganga, covering the river stretch from Gangotri to Narora, the middle Ganga, extends from Narora to Buxar, and the lower Ganga, from Buxar to Hooghaly.
The newly created Ministry of Environmental and Forests, Govt. of India was entrusted the task funding the projects. Each university was asked to conduct the interdisciplinary studies on a definite stretch of the river. Eminent scientist Dr. C.R. Krishnamurthi was requested to head the scientist aspects as chairman. The universities of Uttar Pradesh took active part in this project and a list of institutions along with the names of Principal investigators with address has been summarized in following Table.

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Title of the project</th>
<th>Stretch of the river studied</th>
<th>Name of the Principal Investigators with address</th>
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<td>1.</td>
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<td>Gangotri to Rishikesh</td>
<td>Prof. H.R. Singh Dept. of Zoology, Garhwal University Srinagar, Garhwal.</td>
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<td>2</td>
<td>Integrated study of the river Ganga</td>
<td>Rishikesh to Garhmuktes hwar</td>
<td>Dr. V. Shankar Dept. of Botany, Gurukul Kangri Vishwa Vidyalay, Haridwar.</td>
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<td>3</td>
<td>Pollution modeling of the upper Ganga basin</td>
<td>Garhmuktes hwar to Narora</td>
<td>Dr. R. P. Mathur Dept. of Civil Eng g. University of Roorhee, Roorhee</td>
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<td>Integrated studies of the Ganga Ecosystem between Narora and Kannauj</td>
<td>Narora to Kannauj</td>
<td>Prof. A. M. Siddiqui</td>
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<td>4</td>
<td>a. General water quality measurement</td>
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<td>Dept. of Biochemistry, Aligarh Muslim University, Aligarh.</td>
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<td>b. Taxonomic studies of bacteria.</td>
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<td>c. Man – river interaction from land use: Geographic points of view.</td>
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<td>Physico-chemical studies of the Ganga water from Kannauj to Shuklaganj.</td>
<td>Kannauj to Shuklaganj.</td>
<td>Dr. U.K. Pande</td>
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<td></td>
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<td></td>
<td>Dept. of Zoology, D.B.S. college, Kanpur (S.S.M. University, Kanpur)</td>
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<td>6</td>
<td>Biological studies of the Ganga Ecosystem Between Kannauj to Shuklaganj.</td>
<td>Kannauj to Shuklaganj.</td>
<td>Dr. A.C. Shukla</td>
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<td>Dept. of Botany, Christ Church College, Kanpur (S.S.M. University, Kanpur)</td>
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<td>7</td>
<td>a. Comprehensive study of the Ganga</td>
<td>Shuklaganj to</td>
<td>Dr. A k. Sinha</td>
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<td></td>
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<td>Dept. of Botany</td>
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<td>8</td>
<td>Plant population community structure and function of riparian and aquatic macrophytes in the relation to pollution of the river Ganga.</td>
<td>Mirzapur to Ballia</td>
<td>Dr. R.S. Ambasht CAS in Botany Banaras Hindu University, Varanasi.</td>
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<td>9</td>
<td>Physico-chemical and biological characterization of the river Ganga in relation to pollution.</td>
<td>Mirzapur to Ballia</td>
<td>Dr. B.D. Tripathi CAS in Botany Banaras Hindu University, Varanasi.</td>
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<td>10</td>
<td>Physico-chemical and Physiological assessment of heavy metal pollution in the river Ganga.</td>
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<td>Dr. L.C. Rai CAS in Botany, Banaras Hindu University, Varanasi.</td>
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<td>Mirzapur to Ballia</td>
<td>Dr. D.C.Rupainwar Instt. Of Technology Banaras Hindu University, Varanasi.</td>
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<td>Co-ordinated study of river Ganga: Civil Engineering</td>
<td>Mirzapur to Ballia</td>
<td>Dr.U.K. Chaudhary Dept. of Civil Engg.</td>
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<td>No.</td>
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<td>13</td>
<td>Co-ordinated study of river Ganga: Study of the river water pollution at Varanasi and Prevalence of gastrointestinal morbidities.</td>
<td>Mirzapur to Ballia</td>
<td>Dr. T.C. Tiwari and Dr. P.C. Sen Dept. of Microbiology Banaras Hindu University, Varanasi.</td>
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<td>Hydro geological study regarding the pollution of the river Ganga. (Hydrogeological aspects)</td>
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<td>Dr. G.C. Chowdhari Dept. of Geology, Banaras Hindu University, Varanasi.</td>
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<td>15</td>
<td>A study of the submerged and aquatic plants of medicinal and antipollution value in reference to the Ganga water pollution.</td>
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<td>Dr. R.H. Singh Dept. of Pharmacology Banaras Hindu University, Varanasi.</td>
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<td>Role of sediment in attenuation of trace of metals in polluted aquatic environment of the river Ganga: Sedimentological aspects.</td>
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<td>Dr. M.N. Mehrotra Dept. of Pharmacology Banaras Hindu University, Varanasi.</td>
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<td>Mirzapur to Ballia</td>
<td>Dr. A.K. Mittal, Dept. of Zoology</td>
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<td>No.</td>
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<td>18</td>
<td>Water pollution and endocrine imbalance with special reference to high thyroid physiology and reproduction in some important food fishes.</td>
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<td>Dr. P.T. Singh Dept. of Zoology; Banaras Hindu University, Varanasi.</td>
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<td>A study of the river Ganga with reference to environmental and socio-economic awareness (extension activity)</td>
<td>Mirzapur to Ballia</td>
<td>Dr. Krishna Bahadur Dept. of social Science Banaras Hindu University, Varanasi.</td>
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<td>20</td>
<td>Co-ordinated study of the river Ganga (Agricultural aspects)</td>
<td>Mirzapur to Ballia</td>
<td>Dr. R.C. Tiwari Dept. of Soil Chemistry Instt. of Ag. Sciences Banaras Hindu University, Varanasi.</td>
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</tbody>
</table>

Upadhyay et al (1982) studied the impact of mass bathing on the water quality of river Ganga at Sangam (Allahabad) on the occasion of Ardh Kumbha in 1982 and reported that most of the physico-chemical parameters exhibited high values. Total dissolved solids and total suspended solids were remarkable high and water was found to be unfit for human use. Their observations were in
consonance with those of Sinha et al (1986), who assessed water quality of Ganaga at Dalmau (Rae Bareli) on the occasion of Kartik Purnima, an important mass-bathing day of the district in 1985. Their findings also clearly revealed that the intensity of pollution was greater on the main bathing day though there was no discharge of public sewers or industrial effluents at and around the sampling sites. It has been proved beyond doubt that mass bathing on the occasion of Hindu festivals deteriorates the water quality of the Ganga (Misra & Singh, 1987) and increases the bacterial pollutions along with the organic pollutants in the river water significantly (Singh et al. 1988).

Chandra and Mathur (1983) observed that change in colour and quality of Ganga river water was mainly due to discharge of raw sewage and industrial wastes at Kanpur. Similar conclusions were drawn by Rambilas and Kayastha (1983) during their course of studies of river water at Varanasi.

Impact of sewage disposal on physico-chemical parameters of Ganga water at Varanasi was studied by Sikandar & Tripathi (1984) at six sampling sites viz. Assighat, Harischandraghat, Dasashwamedhghat, Manikarnikaghhat and one control at the upstream of the river where it receives least amount of sewage and other wastes. At these sites except the control one, diverse human activities viz., mass bathing and cremating dead bodies are common. It was reported that all the Physico-chemical parameters exhibited high values and water was found to be highly polluted at all the sites except at control one due to discharge of municipal and industrial wastewater. It was further observed by Pandey & Tripathi (1984) that river water at almost all the bathing ghats was much deteriorated and contained several impurities.
Studies conducted on snowfed river Bhagirathi by Sharma (1984) revealed that river water was fairly clean and showed lower values of turbidity and pH and high concentrations of dissolved oxygen.

Regular water quality monitoring of the river, Ganga was initiated by Central Pollution Control Board (Das Gupta, 1984) at sixteen stations between Rishikesh and Diamond harbor, out of which Rishikesh, Kanpur, Dalmau, Allahabad, Varanasi are in Uttar Pradesh. They observed highest BOD in the river between Kanpur and Allahabad indicating that the river is seemingly incapable of assimilating the organic load discharged into the river.

Another notable event occurred in the late 1984 when the central Ganga Authority was created under the chairmanship of then Prime Minister Rajiv Gandhi after it was felt that the problem of Ganga pollution is of such multifaceted dimensions that only an appropriate authority can take it. The central Ganga authority formulated a Ganga action plan which envisages diversion and treatment of waste water / effluents, use of bio-gas released from treatment of effluents as a principal source of the energy, use of treated effluents as an irrigant and as a source of Pisciculture and Aquaculture and improving the water quality of the river.

Ajamal et al (1984) reported bioaccumulation of metals in submerged plants and fishes of Ganga ecosystem. Agarwal and Srivastava (19894) at about the same time reported that discharge of waste water by various drains into river Ganga & Yamuna at Allahabad, polluted rivers badly at around the discharge point. Other studies which indicate the sewage, industrial wastes and run off water from agricultural fields are main pollutant of river Ganga include

It was Singh (1985) who after an extensive survey of Bhagirathi ecosystem studied the ecology from Gomukh to Deoprayag. He concluded that river water had high velocity, high dissolved oxygen and low temperature.

Chandranand Mathur (1986) conducted studies on the effect of tannery wastes discharge on water quality of Ganga at Bithoorghat and Bengalighat in Kanpur and noted that huge discharge of wastewater had significantly polluted the river water at Bengalighat ultimately causing public health hazards.

Improper disposal of domestic sewage was identified as a major water pollutant at Rajghat, Varanasi by Prasad et al (1986). They further pointed out that bathing and washing by human being of dead bodies and throwing the carcasses intensify the problem of river pollution.


In their annual technical reports submitted to the Ministry of Environment and Forests, Govt. of India, the principal investigators reported the observations on physico-chemical characteristics of the river in the stretch allotted to them, Singh (1986) reported his observation on the river between Gangotri and Rishikesh, Shankar (1986) between Rishikesh and Garhmukteshwar, Mathur (1986) between Badrinath and Narora and Sinha (1986) between Shukalganj and Kalakankar. The annual report of 1986 of ministry of environment and forests, Govt. of India also concludes that about 75% of the
pollution of the river Ganga caused by municipal wastes and maximum BOD value was observed at Kanpur.

The river water of Alaknanda, Which joins the main stream at Devprayag was also reported to be contaminated by several pathogenic bacteria at Srinagar, Garhwal a river side town of Himalayan region in Uttar Pradesh (Nautiyal et al 1986). They concluded that water is also heavily polluted that further negligence may take a heavy toll of human life.

Sangu et al. (1987) during their course of studies of river Ganga at Garh Mukteshwar concluded that water quality of the river on the right bank was much below the prescribed limits recommended for bathing and drinking as compared to the right one. Goel (1987) reported that river water was much polluted at Kanpur as 186 polluting industries generate 40 MLD wastewater, which is discharged ultimately into river at Kanpur, was discussed by Bhargava (1987).

Physico-chemical parameters of Ganga water in and around Varanasi were analyzed between Jan. 1986 and June 1986 by Mathur et al (1987) with reference to heavy metal pollution within a stretch of 12 km. They concluded that river was polluted with CU, Cd, Cr, Co, Pb, Ni, Mn and Zn particularly at the points of sewage outfall.

Observations of physico-chemical and microbiological studies on the river Ganga at Dalmau, Rae Bareli were reported by Sinha etal (1988). According to them higher values of some of the parameters might be due to the practice of cremation of the dead bodies and dumping of half burnt human bodies and carcasses. These contentions were confirmed by Srivastava et al
(1988) who showed that disposal of the dead bodies and carcasses into river Ganga was the main cause of the pollution of the river at Dalmau.

Singh and Srivastava (1988) noted high value of BOD & COD in Ganga water during summers due to high input of organic pollutants and reduced rate of flow between Ballia and Buxar, Saikia et al (1988) at about the same time carried out studies on the impact of human activities and heavy metal pollution of Ganga from Badrinath to Narora within a stretch of 480 km. A total of seven heavy metals viz. Fe, Co, Mn, Ni, Co, Cd and Zn were analyzed and it was pointed out that the concentration of metals in river water was below the permissible limits probably due to the minimum human interference. Contrary to this Srivastava et al. (1989) conducted studies on river Bhagirathi for certain physico-chemical parameters and their seasonal variation and concluded that the middle stretch of river was under pollution stress.

At about the same time Shankar (1988) studied river Ganga between Hardwar and Rishikesh to identify major sources of pollution. It was reported that upstream water was degraded in respect of BOD & COD and Do as number of drains viz. Sarwati Nalla and IDPL Nalla at Rishikesh and BHEL Nalla at Hardwar pour down huge quantities of industrial and domestic wastes along with number of small sewage drains. An average of bacterial counts exhibited an increasing trend down stream from Rishikesh as river received progressively huge amounts of domestic discharge.

Physico-chemical and biological characteristics of river Ganga water and sediments between Shuklaganj (Unnao) Jajmau (Kanpur) were studied by Sinha et al (1989) at four sampling sites. An analysis of eighteen important physico-chemical parameters revealed that river water at Jaimau pumping
station exhibited high values of almost all the parameters than those of remaining other sites. Concentrations of BOD & COD, total nitrogen and conductivity were observed to be higher at all the sites while those of Ca, Mg, hardness, chlorides and Sulphates were lower than the limits. Physico-chemical characteristics of sediments varied with the site. Seasonal variations in the parameters studied were also observed.

Srivastava et al (1989) carried out studies on physico-chemical properties of river Ganga water Buxar (Unnao) during May 1986 and April 1987. An analysis of a total of twenty-three parameters clearly revealed that extent of pollution varied in different seasons. Usually all the parameters showed high values in summer and lower during monsoons except turbidity, which was high in rainy season. Values of BOD, COD, DO and H2S were recorded high than tolerance limits while concentrations Ca, Mg, SO4 and hardness were observed to be lower than the permissible limits throughout the course of study. They suspected that probably generation capacity of Ganga water could not keep pace with the input of water pollutants at Kanpur situated at 50 km. upstream from the study point. At about the same year high concentrations of NO3-, PO4--- at Jajmau pumping station, Dalmau, Gokana, Chandrapur and Buxar were reported by Srivastava et al (1989).

Water quality of river Ganga at Kalakankar (Pratapgarh) was assessed by Sinha et al (1989). It was concluded that even at such a remote and undisturbed place like Kalakankar the river water was not safe for drinking and bathing. It was also noted that the river showed an alkaline trend throughout the course of study.
The river Ganga between Karemanikpur and Phaphamau (Allahabad) was studied by Sinha et al (1989) in the same year for certain important physicochemical parameters and their spatial and temporal variations. Water sample were collected from five sampling sites downstream from Karemanikpur viz. Kare Manikpur, Haudenshwar, Natn ghat, Shringverapur, Phaphamau bridge eastern side and western side of the bridge during Sept. 1987 and August 1988. It was observed that the level of dissolved oxygen gradually decreased from Karemanikpur to Shringverapur due to input of rural wastes while total dissolved solids exhibited reverse trend. Turbidity was recorded maximum at Phaphamau and most of the parameter exhibited monthly variations at all the sites. It was concluded that despite appreciable improvement in the water quality a compared to Shuklaganj, river water was still not fit for human consumption. Water quality index (WQI) of river Ganga between Shuklaganj (Unnao) and Kalakankar (Pratapgrah) were calculated by Sinha et al (1989) using the procedure of Tiwari et al (1986). On the basis of water quality indices calculated, Shuklaganj, Jajmau pumping station and Dalmau were severely polluted while the rest of sites were moderately to severely pollute.

Shukla et al (1989) conducted studies on the physicochemical and biological characteristics of river Ganga between Mizapur and Ballia a stretch of 225 km. from sept. 1984 to August 1986. Their observations clearly revealed that river water was tolerably good at the points where it enters the city and was highly polluted at midstream due to large input of sewage and industrial wastes. They reported that down – stream water at Varanasi was highly polluted, as compare to other sites because 63 MLD sewage and industrial effluents were discharged into the river through Rajghat Nalla while water quality at Ballia
was fairly clean. Total coli form count was reported to be high in midstream sample of river at all the sampling sites.

Ecological studies and physicochemical characteristics in relation to phytoplankton productivity were conducted by Shukla et al. (1989) at Varanasi from March 1986 to Feb. 1987 at four sampling sites viz. Samneghat, Assighat, Dasashwadhghat and Rajghat and noted that river was polluted at all the sites except Samneghat with respect to BOD & COD.

Physico-chemical properties of Ganga water at Farukhabad were studied by Kudesia (1989) who found that the main pollutants of Ganga at Farukhabad were domestic and industrial wastes. Singh and Misra (1989) evaluated the status of major rivers in Uttar Pradesh on the basis of data available with U.P. pollution Control Board pertaining to the physicochemical parameters of river Ganga and concluded that the Ganga water from Farukhabad to Ghazipur within a stretch of 600 kms. was highly polluted and was unfit for drinking and bathing without proper treatment. Water quality was however; found to be satisfactory at Rishikesh while it was most polluted at Kanpur.

Concentration of heavy metal in river Ganga water between Karemanikpur (Pratapgarh) and Phaphamau (Allahabad) was studied by Sinha et al. (1990). It was observed by them the values of Ni, Cd, Cr, Pb, Mn and Fe in the river water were higher at all the selected sites indicating that the heavy metals have flowed down to the sites of study.

Sediment characteristics of river Ganga at Shuklaganj (Unnao), Gegasso (Rae Bareli) and Phaphamau (Allahabad) were reported by Sinha et al. (1991). It was concluded by them that mass bathing caused measurable change in the
water quality of the river. The pollution load increased during mass bathing making the water unfit for even bathing.

Observations on a comprehensive study of river Ganga in the stretch between Kalaknkar (Pratapgarh) and Phaphamau (Allahabad) were reported by Sinha (1991). Based on two-year study of the river he concluded that the river was moderately to heavily pollute in this stretch. The river water in this stretch also showed high concentrations of certain heavy metals and presence of commonly used pesticides. The sediments of thee river in this stretch was also observed to act as a reservoir of the pollutants that are thrown in the river.

Physico-chemical properties of city sewage discharged into river Ganga at Varanasi were investigated by Tripathi et al (1991) at six sampling sites i.e. Assighat, Shiwalaghat, Harischndraghat, Chaukighat, Rajendra Prasad ghat and Rajghat. It was reported that Rajgaht sewage was highly concentrated while that of Assighat was less concentrated. There existed a monthly variation in pollution load of waste water which was highest in the month of June and values reported for BOD & COD were 30428 kg / day respectively.

Sinha et al (1992) concluded studies on the impact of the mass bathing on diurnal variation of physico-chemical parameters on Makar Sankranti day at Kanpur and reported that most of parameters were in lower range during night and higher during daytime except dissolved Oxygen and temperature. Appreciable increase in bacterial count and turbidity and lower values of D.O. were recorded when bathing activity was at its maximum. Shukla et al (1992) assessed the water quality of river Gnaga at Ghazipur in the same year and concluded that most of the important physico-chemical parameters exhibited
higher values that the tolerance limit while Israeli (1992) noted the presence of heavy metals in Ganga water and sediments throughout the course of study.

River Bhagirathi between Uttar Kashi and Tehri was surveyed for limnobiotic studies by Joshi et al (1992) while Srivastava et al (1993) conducted studies on the pollution status of river Ganga and its impact on sediments at Mirzapur. Water quality of the river Ganga in District Rae Bareli was studied by Sinha et al (1993) and that at Mirzapur and Ballia by Srivastava and Mehrotra (1993)

Srivastava et al (1994) carried out investigations on pesticides residues in Ganga water between Kare Manikpur (Pratapgarh) and Phaphamau (Allahabad) during Jan 1988 and June, 1988 and concluded that among organo-chlorine pesticide (OCP) the concentrations of DDT, BHC and Endosulfan were found to be higher when compared with the EP limits for fresh water aquatic live stock at almost all the sampling sites. Organo-phosphorus pesticides (OPP) could not be detected. The entry of pesticides into the river system was attributed to agricultural run off. Physico-chemical characteristics of river Ganga water between Kannauj to Shuklaganj exhibited a variety of difference as the river in this stretch from Manimau to Bithoor traverses through agricultural belt receiving agricultural washouts and thereafter up to Shuklaganj (Unnao) through highly industrialized area. The industrial effluents enters into river water at Shuklaganj which contain major pollutants like phosphates, sulphates, Ca, Mg, Fe, Mn, Na, Co, Ni, Pb, Zn, Cd, along with organic wastes viz. barks of tree, hair, fleshing and other tannery products. Thus river water quality progressively deteriorates from Manimau to Shuklaganj having maximum pollution load at Shuklaganj. Likes wise the populations of microbes
increasing trend with increased level of pollution within the stretch (Shukla and Anjum, 1984).

Kumar et al (1994) also studied the soil characteristics on the riverbanks and established a correlation between the soil characteristics and growth of Bryophytes.

Singh and Sinha (1995) discussed the problems and prospects of water pollution especially those of river population and suggested certain remedial measures.

In an article entitled Pollution status and health Hazards of river Gnaga, Sinha (1996) expressed his concern on the increasing pollution of river in spite of Ganga Action plan and feared that this may results in higher health risks.

**River Yamuna:** Originating at Yamunotri and merging with river Ganga at Allahabad River Yamuna, thought a major river of Uttar Pradesh, also passes through Delhi, the Capital of the country. Chakraborty et al (1959) were probably the first to study the physico-chemical condition of Yamuna at Allahabad during 1954-55. They were followed by Mohan and Sarkar (1961, 1965) and in their preliminary investigations on pollution status of river Yamuna at Delhi concluded that its water was degraded and was unfit for drinking and bathing. Mathur (1965) studied the river Yamuna at Delhi and reported deterioration in its water quality while Bhargava (1984) felt an immediate need to monitor the river Yamuna to prevent the pollution. Similar observations were made by Rai (1974a), Dakshini (1979), Madhwal (1983) and Kumar (1984).

Sangu and Sharma (1985) assessed the river quality at Agra and observed that it was significantly polluted and unfit for human use. Similar
observations were made by Chaturvedi (1985) in the same year and it was concluded that the water quality of river Yamuna has significantly deteriorated in Uttar Pradesh.

Analysis of trace metals in river water and treated effluents of Delhi sewage disposal plant was carried out by Wassay and Jain (1988) along with the soil samples at a place where treated effluent is used for irrigation purposes. The presence of toxic metals were reported from the samples collected and remedial method was suggested for their removal by recycling of water with expanded bed of sand particles coated with naturally occurring polyelectolytes extracted from the alluvial soil of the river.

Singh and Mishra (1989) assessed the water quality of river Yamuna at Mathura, Agra, Etawah an Allahabad and observed that the river was badly polluted at Mathura, Agra and Allahabad as the BOD values within the stretch valued from 1.5 mg / lit to 30.3 mg / lit in different seasons while the total coliform count ranged between 1820 to 63500. However, significant improvement in the water quality at Etawah was observed through the coliform (MPN) count was quite high, ranging from 7000 to 210000 probably due to sewage disposal. The river of Allahabad was found to be severely polluted with BOD values ranging between 7.7 mg /lit to 30.3 mg /lit. in different seasons due to direct discharge of industrial effluents and municipal wastes. They found the water quality below the desired levels at all sites and suggested that the whole river needs proper treatments before any human usage.

Neeraj and Pankaj (1989) studied the effects of effluents on the sediments and mineralization of river Yamuna in and around Delhi region and concluded
that the river Yamuna water coming out of Delhi is heavily polluted with sewage effluents and high rate of sedimentation.

Studies of water quality and metal speciation in river Yamuna were conducted by Gadhi et al (1991) between Dakpathar and Agra and progressively higher percentage of Cd, Cu and Zn were recorded in the downstream which clearly indicates that pollution load increases as the river receives industrial effluents along its course. Singh et al (1993) assessed the BOD load of river Yamuna in respect of Potable water of Agra during Sept. 1991 to May, 1992 and reported that DO and BOD of river water severely affected due to discharge of municipal sewage and industrial effluents of Mathura and Agra city. On the basis of the above studies it may be said that the water of river Yamuna is unfit for human consumption.

**River Gomati**: River Gomati an important tributary of river Ganga and perennial river of Awadh plains ruse across the major part of Uttar Pradesh covering nine districts and a distance of approximately 940 kms. Originating from Madhoganj Tanda Village in Pilibhit districts, it passés through the districts of Shahjahanpur, Kheri, Hardoi, Sitapur, Lucknow, Barbanki, Sultanpur, Jaunpur and ultimately merges in river Ganga near Saidpur town of district Ghazipur. During its course, it receives huge quantities of untreated sewage and industrial wastes, which alter the physico-chemical characteristics of river water significantly.

It was Bhaskaran et al (1965) who initiated physico-chemical studies on the river at Lucknow. They concluded that the river water was significantly polluted and despite self-purification capacity, it showed lower values of dissolved oxygen at certain points in summers.
Arora (1973) observed that river Gomati at Lucknow was severely polluted as 33 waste outfalls were discharged approximately 21.26 MGD untreated wastewater into it. It was also noted that the river water quality did not improve up to the desired level even after it had traveled 65 km. downstream from Lucknow.

Hydro biological studies on the river Gomati with reference to eutrophication were carried out by Prasad & Saxena (1980) within a stretch of 11 km. in Lucknow city from Feb. 1975 to Jan 1976. They also carried out investigations of physico-chemical parameters in relation to occurrence of blue green algae. From the observations they concluded that there was clear relationship in total solids, pH, rainfall and atmospheric temperature. Direct relationship between total solids and rainfall was reported during the course of study while the same was not well defined with temperature. An inverse relationship was noted between pH and total solids at all the sampling sites. It was further reported that there exhibited a direct interdependence between pH and Carbonates which confirmed that river was rich in Carbonates. According to them blue green algae showed more or less definite zonation in relation of physico-chemical parameters and exhibited a gradient through progressive degree of pollution.

Prasad and Singh (1982) carried out studies on physico-chemical characteristics and species diversity of diatoms, which are reliable bio-indicators of pollution. River water was analysed for fifteen physico-chemical parameters at four sampling stations including one at a point where river enters Lucknow city. They conclude that addition of sewage in the river has caused a reduction in mean values of DO and transparency and an increase in
bicarbonates, total alkalinity, chlorides, total hardness, calcium, Magnesium, and free saline ammonia.

Kumar and Kant (1987) analysed the water of the river Gomati at Lucknow for certain heavy metals and observed that it was polluted with Cu, Zn and Cr. The concentration of metals was found much higher the permissible limits and it was suggested that river water was not safe for human usage without proper treatment.

Impact of industrial waste water of distilleries and sugar mill on the water quality of river Gomati and it tributaries was studied by Singh an Misra (1989) who concluded that BOD values in river water ranged between 5.2 mg/li (Gaughat upstream) and 59.5 mg /Lit. (Wazirganj Nala) in summer, 3.4 mg /lit. (Naimisharanya) and 210 mg/lit (Mohan Meakin Nala D/S) in post monsoon and 5.1 mg /lit (Gaughat U/S) and 850 mg /lit (Mohan meaking Nala U/S) in winter seasons. The total coli from counts (MPN) were observed to range from 20 (Mohan Meakin Nala D/S) to 2,40,000 (Wasiranj Nala D/S and Jaunpur D/S) in summers, 780 (Namisaranya, sitapur) to 2200 (Gaughat U/S) to 24000 (Jaunpur D/S) in winter seasons at different places. Physico-chemical parameters and microbial counts (MPN) clearly revealed that river was grossly polluted at Lucknow and Jaunpur due to discharge of large quantities of raw sewage and industrial wastes.

Studies conducted on tributaries of river Gomati viz. Sarayan at Sitapur and Gone at Kamalapur in the same year by Singh and Misra (1989) indicated that both of them were significantly polluted due to discharge of sugar mill effluent and distillery waste water in their catchment area.
Bhatt and Pathak (1992) conducted studies to assess the pollution status of river Gomati within a stretch of river draining the Kumaon region and observed that several physico-chemical parameters exhibited seasonal variations. They further reported that natural water of river was BOD free and possessed a low ionic strength with a dominance pattern of Ca$^{++}$, Na$^+$, Mg$^{++}$, K, HCO$_3^-$, Cl$^-$, SO$_4^{--}$. The river water was found to be tolerably clean and contained biologically important nutrients while it gets highly polluted downstream due to human interference and input of municipal and industrial wastes water.

Misra et al (1994) studied river Gomati and its tributaries viz. Kathna, Sarayan and Gone at Shahjahanpur, Kheri, Sitapur, Hardoi, Lucknow, Barabanki, Sultanpur, Jaunpur and Varanasi before its confluence with river Ganga at Ghazipur. The river Gomati water was monitored at nineteen sampling sites between Nov. 1987 and Oct. 1990. From the observations they concluded that the river was grossly polluted at Shahjahanpur, Kheri and Lucknow as BOD and COD values were quite high at these sites in winter and summer seasons. Comparatively lower values of BOD and COD at Sultanpur and Jaunpur in the same seasons during course of study clearly indicate the self-purifying capacity of river water. Dissolved oxygen and pH values of river water ranged between 4.8 mg/lit. to 9.4 mg/lit and 7.1 to 8.8 respectively at all sampling stations during the study period, which indicated that river, showed alkaline trend throughout. Mean values of twelve selected parameters of Sarayan River indicated that it was polluted at downstream Sitapur BOD & COD values were quite high particularly in winter and summer seasons. Lower values BOD & COD in the river water during monsoon were attributed to the
dilution of the wastes discharged into it while turbidity was observed to be maximum at all sampling stations in same season. River Kathna that joins river Gomati near Qutabnagar (Sitapur) was surveyed at upstream Kheri and upstream Quatnagar and was found grossly polluted at both the sites. Similarly river Gone which is a tributary of river Srayan receives considerable domestic and industrial effluents near Hargaon town (Sitapur) and was observed to be most polluted throughout the year at Kamapur and Hargaon town.

**River Sai:** River Sai a major tributary of river Gomati originated from Uchaulia Nalla situated in the northern side of Pihani in Hardoi district. It transverse through the districts of Unnao, Rae Bareli, Pratapgarh and Jaunpur covering the distance of approximately 450 km. In the recent past these districts have witnessed rapid industrial growth and urbanization. Ultimately river Sai merges with river Gomati at Rajapur Trimuhani near Jalalpur in Jaunpur district. The river has been used as sink for dumping off domestic sewage since long which has increased enormously in last few years due to increased urbanization and population growth. Moreover rapid industrialization in Unnao and Rae Bareli districts has increased the effluent quantity considerably which is discharged into the river Sai.

Studies on water quality or river Sai were initiated by Sinha et al (1985). It was concluded from their preliminary studies on the physico-chemical properties of river Rae Bareli that pH, DO, BOD, hardness, conductivity, total solids, and total dissolved solids were under tolerance limits while concentration of Cr, Cd, Pb, Fe, Co, Ni and Mn were more than the permissible limits of WHO standards. It was confirmed in later studies by Vajpayee et al (1988).
Kumar and Kant (1987) analyzed river water for certain trace elements and noted that it contained detectable amount of An and Mo which was in confirmedly with the earlier observation that river was polluted with toxic metals.

Sai was reported fairly clean at Pihani as it exhibited lower values of BOD (1.2 mg/lit.) and bacterial counts which ranged between 240 – 480 (Singh and Misra, 1989).

Detailed studies on the hydro-chemical characteristics of the river water were conducted by Srivastava (1991) from Gausganj (Hardoi) to Rajapur Trimuhani (Jaunpur) between Nov. 1990 and Dec. 1991 in Mansoon, winter and summer seasons. Analysis of water sample collected from eleven sampling sites clearly indicated that river water at Rae Bareli and Pratapgarh was highly polluted in winters and summers. This was probably due to untreated discharge of sewage and industrial effluents into the river. It was also reported that river water was fairly clean at Gausganj and Rajapur Trimuhani as compared to Rae Bareli, Pratapgarh and upstream of Jaunpur city indicating clearly the regeneration capacity of river. The river water was observed to be below the desired levels for drinking and bathing except Gausganj when with ISI and WHO standards.

Comparison of water quality of the river Sai at the point of origin and confluence was studied by Srivastava et al (1992).

It was concluded from the studies that the quality of water of river at the origin was better than that at its confluence presumably because the river gets polluted due to discharge of urban sewage, industrial effluents and agricultural run off.
In the same year Srivastava et al (1992) monitored the quality of the river water at Bala (Pratapgarh) as effected by mass bathing during Navatri festivals. It concluded from the results that mass bathing caused a significant deterioration of the river water quality, which might pose a health hazard to the users of the river water.

Sinha et al (1994) conducted studies of the physico-chemical properties of industrial wastewaters of the paper mill at Rae Bareli, which is discharged into river Sai and noted that it showed high values of COD & BOD and total suspended solids. The concentration of dissolved oxygen was much lower than the permissible limits throughout the study period and effluent was suspected to damage the local flora and fauna.

Srivastava et al (1994) conducted studies on the impact on the mass bathing on the physico-chemical characteristics of the river Sai water on an important Hindu festival ‘Mahashivratri’ near Rampur Sadauli village at Rae Bareli where an old temple of Lord Shiva ‘Bhaureshwar Nath’ is satiated on the left bank of river. The place has marked geographical importance as the boundaries of the districts of Lucknow, Rae Bareli and Unnao meet here and because of its mythological and historical importance, mass bathing and a fair is organized every year. The river water was analysed for a total of fifteen important physico-chemical parameters and was reported that most of them exhibited higher values. They noted an increase in the values of pH, turbidity, DO, BOD, Hardness, total solids, total dissolved solids, total suspended solids and chlorides due mass bathing while alkalinity of river water surprisingly decreased with increase in the bathing activity. Moreover Ca, showed higher values and Mg was found in lower concentrations when compared with the recommended limits of
ISI (1983). They also reported that phytoplankton and zooplankton density and populations of benthic flora and fauna were also remarkably affected by an increase in bathing activity and exhibited a gradual decreasing trend.

On the basis of data obtained by analysis eight physico-chemical parameters of river Sai water during 1988 to 1990 at six sampling sites viz. Lohanipur, Rajghat, Munsiganj, Dariyapur, Jagdishpur and Behtra Khurd, water quality index (WQI) of the river was calculated by Sinha et al. (1994). It was concluded that water at Rajghat, Dariyapur, Jagdishpur and Behtra Khurd was severely polluted while at remaining sites moderately to excessive polluted. It was observed that WQI usually decreased during August and increased in May due to variation in the volume of water in monsoon and summer seasons.

Impact of sugar factory effluents on physico-chemical characteristics of river Sai at Rae Bareli was studied and reported by Srivastava et al. (1995). It was concluded by them that the physico-chemical characteristics of the river water changed due to the addition of sugar factory effluents into the river. The river water got deteriorated and become unfit for human consumption during the season of the operation of the sugar factory.