CHAPTER I
LITERATURE REVIEW
Considerable work has been done to study the physico-chemical characteristics of the different natural water systems. Due importance has been given to the effect of industrial and domestic effluents on such characteristics. Foreign river systems have been more extensively studied than Indian river systems.

Practically very little information is available regarding the rivers in Uttar Pradesh. Physico-chemical characteristics of the river Ganga, used as a measure of water pollution level, at Kanpur were studied during the pollutional studies of the river, made by Saxena et al.\(^1\) in 1966. pH, temperature, turbidity (as SiO\(_2\)), alkalinity (as CaCO\(_3\)), hardness, chlorides, total solids, dissolved oxygen, biological oxygen demand, nitrate-nitrogen, phosphate as PO\(_4^{3-}\) and tannins were the subject of main discussion. An increase in temperature of river water was observed at the discharge-point of condenser water from the power house of the KESA. pH of the stream was found affected by the textile industry effluent discharge and city sewage discharge. Seasonal studies were simultaneously made for dissolved oxygen (DO) and biological oxygen demand (BOD) variations. The highest BOD values were recorded during the summer season. A relationship between DO and BOD was also established. Self purification constants were also determined for the river.

A short term physico-chemical study of the river Ganga at Kanpur, has been made by Pandey et al.\(^2\). The study was performed at intervals of one month for the year 1977. The main specific and non-specific characteristics as studied were BOD, DO, COD, ammoniacal nitrogen, sulphide, sulphite,
sulphate, chloride total hardness total solids, pH, temperature and electrical conductivity. Seasonal variation in these characteristics was also studied. Five days BOD reached upto 55 ppm at certain places in the downstream. Total chromium varied from 1.86 to 2.02 ppm at the points where effluents from the tanneries are discharged.

The water quality of river Pandu at Kanpur was studied by Srivastava\(^3\) in April 1972. Average river water composition as determined, is given below:

<table>
<thead>
<tr>
<th>Chemical species</th>
<th>mg/L</th>
<th>Chemical species</th>
<th>mg/L</th>
</tr>
</thead>
<tbody>
<tr>
<td>Na(^+)</td>
<td>6.3</td>
<td>SiO(_2)</td>
<td>13.1</td>
</tr>
<tr>
<td>K(^+)</td>
<td>2.3</td>
<td>Cl(^-)</td>
<td>7.8</td>
</tr>
<tr>
<td>Ca(^{++})</td>
<td>15.0</td>
<td>HCO(_3)</td>
<td>58.4</td>
</tr>
<tr>
<td>Mg(^{++})</td>
<td>4.1</td>
<td>SO(_4^{--})</td>
<td>11.2</td>
</tr>
</tbody>
</table>

The nitrifying becaterias were also found to develop with ammonia and urea act as substrate. Arora et al\(^4\) have made an effort to study the dispersion characteristics and concentration level of the dissolved nitrogen species discharged from the fertilizer plant (I.E.L., Kanpur) into the river. They measured the NH\(_3\) -N, NO\(_3\) -N, NO\(_2\) -N and organic -N concentration level in the downstream and upstream above the point of discharge. Hydrolysis was accounted for the conversion of most of the urea (dissolved) to dissolved ammonia. Concentration levels as studied were indicative of low nitrification rate in the stream.

Pollutional characteristics of the waste water discharge from the fertilizer factory (I.E.L., Kanpur) into the river Pandu have been studied by Jain.\(^5\) He studied the seasonal variation in oxygen demand characteristics (BOD and COD), nitrogenous species (NH\(_3\)-N, NO\(_3\)-N, NO\(_2\)-N and Urea-N) and water quality physical characteristics (pH, temperature and electrical conductivity). Nitrification and denitrification characteristics of the effluent were also studied.

Similar studies on the water quality of Yamuna, Ganga and Kalinadi has been performed by Bhargava et al\(^6\). Very little work on the chemical characteristics of the river Gomti has been done, majority of the studies made so far has been based on hydrobiology and other biological characteristics.

Mathur\(^7\) has studied the physico-chemical and biological characteristics used as a measure of pollution level of river Yamuna at Delhi. An ecological survey comprising biological composition, as affected by the industrial discharges, of the river Ganga at Kanpur has been made by Khare et al\(^8\). During the
study, observations were made for the effects of pollutants on the macro-organisms living in the river. Pollution studies of river subarnrekha has been made by Dhaneshwar and Rao. Seasonal variations in the temperature was observed as 34°C in summe and 15°C in winter. A short term study of physico-chemical and biological characteristics of the river Tapti in Surat region has been made by Shilat et al. Variation in pH, temperature and other chemical characteristics (TS, TSS, DO, BOD, COD, total hardness, sulphate and chloride) were studied for the year 1977. These characteristics were found adversely affected by the effluent discharges from paper mill and thermal power house. The river was found highly polluted with organic matter. A definite ratio (1 : 1.5 to 1 : 2.5) of COD to BOD was observed.

Effects of effluent discharges from the straw-board mills, textile mills, steel factory, and a heavy electrical factory, on the pollution - indicating characteristics of the river SOME in Madhya Pradesh have been studied by Shastry et al.

Besides the study of water quality, a good amount of work has been performed on the dispersion and distribution of nitrogenous species, toxic heavy metals and organic micropollutants. Meijers studied the dispersion of the organic micro-pollutants (hexanol, acetophenones, chloro - and nitrophenols, fatty acids and esters etc.) in river Rhine and Maos in 1974.

Recently, physico-chemical studies, indicative of pollution level of the river Danube (Hungary) were performed by Literathy, with significant attribution to the distribution of micro-organic species, e.g., phenols and petroleum derivatives.

A physico-chemical survey of heavy metal ions and different forms of nitrogen has been performed on South river virginia by John Cairns in 1970. He observed that calcium, magnesium and sodium are distributed at high concentration level. Nitrate-nitrogen concentration varied from 0.14 to 0.42 ppm. Comparative study on organic constituents in polluted and non-polluted aquatic environment (Takya river waters, Tokyo and polluted river, Brook) was made by Genki and Matsumato.

Ogura et al. have studied the chemical composition of micro-organic compounds present in water of river Tamagawa (Japan). Similar type of work has been done by Masumaio, Hanya and others who studied the dispersion of phenols and other aromatic amines in aquatic environments.

Chemical characteristics of small streams near Haney in south-western British Columbia were studied by Feller and others. Mahmud and Ahmad have studied the water quality characteristics of a stretch
of the river Tigris.

Thomson\textsuperscript{22} has proposed a model for NO\textsubscript{2} - N distribution and denitrification in river Thames (England). Many other studies have been performed on the nitrogen species including their mutual transformations in the natural streams\textsuperscript{23-25}. Little work has been done to study the dispersion of residual chlorine, cyanides\textsuperscript{26} and sulphides in natural waters.

Attention has also been paid towards the pollution caused by the presence of toxic and non-toxic elements. Recently, a lot of work has been done on the dispersion and distribution of heavy metals viz., chromium (VI), lead, cadmium, mercury, arsenic, zinc and selenium. Hydrolysable metal ions viz., iron and manganese have also been studied. Correlations of the physical constants and chemical factors with concentration of metal ions have also been established.

Going through the available literature, it is concluded that most of the studies on metallic distribution have been performed in other parts of the world than in India. Helz et al\textsuperscript{27} have studied the dispersive behaviour of metals such as manganese, copper, zinc, cadmium and lead discharged from a waste-water treatment plant into an estuarine environment (Back River, M.D.). Water, sediment and waste-water samples were analysed for the total and dissolved concentration of the metals. They observed an abnormal decrease followed by a sudden increase in the concentration level of iron and manganese in downstream. Their work led to the conclusion that remobilisation of the metal ions from the sediment to the surface waters is in action. Electrical conductance was correlated with the concentration level of these metals.

Prater et al.\textsuperscript{28} have studied the dispersion of trace metals discharged from a steel works effluent to the Tees estuary. They concluded that metals (Zn, Cd, Fe, Cu\textsuperscript{+}, Cu\textsuperscript{++}) in the effluents are in suspension and the majority of the total metal load is made up of iron, manganese, zinc and lead.

Pandey\textsuperscript{29} has made an analytical study on trace concentration of arsenic in aquatic environment. Adsorption and distributional studies of heavy metal ions in the polluted waters of river Kallado (Kerala) have been made by Nair et. al.\textsuperscript{30} Their work showed that a fraction of the total concentration of lead, zinc, cadmium, arsenic, bismuth, nickel, chromium etc. is distributed as the adsorbed species on clay-organic matter components of the river mud. Comparision between the concentration level in polluted river waters and clay organic matter was also made by them.

Correlation between the mercury concentration in industrial effluent, their sediments and some other
parameters has been made by Kumar et. al.\textsuperscript{31} Dispersion and distributional studies of lead as Pb (II) in river Periyar has been made by Borkar et al.\textsuperscript{32} Seasonal variation in the lead concentration was also studied. In the pre-monsoon period, the lead (II) concentration level of the river water in the upstream zone was not significant compared to 10-30 $\mu$g/L in the industrial zone and in the back water zone. Their study has not indicated the accumulation of lead by the micro-organisms.

Occurrence of rare alkali ions in natural waters of Uttar Pradesh has been explored by Gaumat and Sahgal.\textsuperscript{33} Hydrochemistry and extent of water pollution by the heavy metals in central Ganga river (India) basin and their impact on regional biology have been studied by the Israelii.\textsuperscript{34}

Model of metal transport above and below the waste discharge in the Hcm river (North Carolina, U.S.A.) has been prepared by Marks Shuman et. al.\textsuperscript{35} with the help of analytical data. Kutrata and others\textsuperscript{36} have studied the dispersion of lead, cadmium, zinc, copper and cobalt in the streams of Cayuga Basin, N.Y. Rao et.al.\textsuperscript{37} have worked on chromium dispersion in natural waters.

Studies on the speciation of the trace metals natural aquatic environments have been made by T.M Florence and Desal et. al.\textsuperscript{38-41} Fukai and others\textsuperscript{42} have studied the variation in the soluble zinc concentration in the river (Var), Estuar coast. Work to study the adsorption of cadmium by the sediments of Tama River (Japan) has also been done.\textsuperscript{43} A chemical survey for the dispersion of trace elements in the rivers Savan and Canning of Western Australia has been made by Taylor and Robert\textsuperscript{44} for the period 1979-80. During the investigation dispersive behaviour of cadmium, chromium, copper, lead, nickel and zinc was also studied. Mair et. al.\textsuperscript{45} have studied the copper dispersion in a water supply reservoir.

A host of workers have contributed to the limnological knowledge of lakes, ponds and pools and notable amongst them are : Birge and Judy\textsuperscript{46}, Hutchinson et al\textsuperscript{47}, Ganapati\textsuperscript{48}, Chandler and Weeks\textsuperscript{49}, Macan and worthington\textsuperscript{50}, Das and Srivastava\textsuperscript{51}, Sreenivasan\textsuperscript{52}, Verma\textsuperscript{53}, Bohra\textsuperscript{54}, Misra et al\textsuperscript{55}, Bohra and Bhargava.\textsuperscript{56}

Records on hydrobiological studies of riverine system are less. This may be due to long stretch of water sheet, varied morphometric, hydrographical and biological conditions of the ecosystem. Some available important records on foreign lotic waters are Allen\textsuperscript{57}, Reinhard\textsuperscript{58}, Butcher\textsuperscript{59}, Eddys\textsuperscript{60}, Chandler\textsuperscript{61}, Berner\textsuperscript{62}, Johnes\textsuperscript{63}, Rzoska\textsuperscript{64}, Holden and Green\textsuperscript{65}, Wright and mills\textsuperscript{66}, Whitton and Dalpra\textsuperscript{67} and Hynes.\textsuperscript{68}

In India, fresh water ecosystems are estimated to have an area of about 1.37 million hectares while the
total length of Indian rivers and their tributaries is about 27,359 Km which offer great potentialities for fishery development. In comparison to lentic ecosystems, very less work has been done on Indian rivers.

The knowledge of riverine hydrobiology is not very old. The first work has started in 1875 in Illinois, on the insects, fish and birds of the illinois river (Forbes). Between 1894 and 1899 Kofoid carried out extensive studies on the plankton and hydrography of the same river and observed that the Illionois river plankton were polymixic owing to the mingling of the plankton from various portions of the drainage basin, specially from connected backwaters and the consequent seeding of the channel water with a great variety of organisms. He also observed that in colder months less plankton was produced as compared to warmer months. Galtsoff studied the upper Mississippi during 1921 and Reinhard surveyed the upper mississippi from Minneapolis to Winona. Lower missouri was studied by Berner who is of the opinion that probably because of the turbidity phytoplankton were less than the zooplankton in the river. Records on the chemical composition of the rivers of the United States were compiled by Clarke. Hydrology and plankton of the river sokoto were studied by Holden and Green who are of the opinion that phytoplankton are more abundant in pool than in river.

Fishes can tolerate only a narrow range of fluctuation in physico-chemical conditions of the river. Many fishes depend upon plankton directly or indirectly for their food. Phytoplankton and zooplankton which are the producers and primary consumers respectively, form the main food chains of any aquatic ecosystem. Kofoid's study on the plankton of Illinois river during 1894-1899 is the first available record on plankton study of riverine system. During summers of 1929, plankton of Sangmon river was studied by Eddys.

Chakrabarty et al. studied the plankton, quantitatively, of the river Jamuna at Manakeshwar ghat, Allahabad during 1954-1955. Jamuna Plankton at Allahabad was again studied by Ray et al. from March 1958 to February 1959. Ganga plankton was also studied (at Varansi) by Lakshminarayana, who found that turbidity of the flood waters of the Ganges reduced phytoplankton density.

Life of plankton, plants and fishes is effected by the variation in physico-chemical conditions of the river. Reports on diurnal variation study of rivers are meagre. Gasu and Ghosh have studied the diurnal variations in a selected stretch of the Hooghly estuary. Bohra studied diurnal variations in chlorophyll pigments in Mandovi estuary in Panji (Goa). Plants which are the main energy source, sometimes put hinderances in fishery development. In this connection reports of river Betwa are important. Sahai and Sinha and Sahai and Srivastava are important. Sahai and Sinha and Sahai and Srivastava have studied the plants of fish ponds.
METAL POLLUTION ABATEMENT:

From the literature up to now available, in connection with metal pollution abatement, it is apparent that physico-chemical and chemical techniques have been explored for the removal of heavy metals (Pb, Cr, Cd, Ni, Zn, As and Mg etc.) from the industrial waste waters that find its way into natural streams.

Removal of hexavalent chromium has been the subject of much discussion. Methods like reduction followed by precipitation, ion-exchange treatment, reverse osmosis and physico-chemical adsorption have frequently been examined for the removal of chromium (VI). Adsorption has been studied mainly with activated charcoal.

Hung et al. studied the adsorption of chromium (VI) from dilute aqueous solution by the use of activated charcoal.

The adsorbed species were found to be $\text{HCrO}_4^-$ and $\text{Cr}_2\text{O}_7^{2-}$. A continuous mixed batch system has been employed for the study. Maximum removal of chromium (VI) has been reported at pH 7.0-9.0. Adsorption data followed the Langmuir isotherms. It was concluded that removal proceeds via the formation of carbon-oxygen complex at the carbon surface. Adsorption was explained by the Couy-Chapman Stern Graham model which accounts for electrostatic and specific adsorption. Calculation of free energy of adsorption was also made. Another adsorption study with activated charcoal has been made by Kumar and Zalltex. The critical pH at which maximum removal of chromium (VI) approached was between 3.4 and 4.0. Complete removal was attained at pH 4.0 at higher concentration level of chromium (VI). At low pH, adsorption effect of chromium (III) was found minimum.

The present work which was conducted in 1990 onwards provides first hand information regarding physical, chemical studies, morphometry, hydrography, micro and macro plants and fishes of the river 'Pandu' at Kanpur. Some information regarding the removal of chromium has also been reported.
REFERENCES


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