Chapter 2

LITERATURE REVIEW

Water is the lifeblood of our bodies, our economy, our nation and our well-being.

Stephen Johnson
2.1. International Research Efforts:

Al-Hogaraty, E. A. et al.\textsuperscript{172} had studied ground water pollution of the quaternary aquifer in northern United Arab Emirates for salinity (TDS), total hardness (TH), dissolved oxygen (DO), cations ($Ca^{2+}$, $Mg^{2+}$, $Na^+$ and $K^+$), anions $HCO_3^-$, $SO_4^{2-}$, $Cl^-$ and $NO_3^-$) and trace elements (Fe, Pb, Cd and Cr). Ali, M.\textsuperscript{84} had studied the effect of seasonal variation of physical and chemical characteristics of mixed water from rivers Ravi and Chenab at union site in Pakistan. Soltan, M. E.\textsuperscript{68} had done chemical analyses of ground water at Zakhera village (Dakhla Oasis, Egyptian Western Desert) and carried out for Water quality index (WQI), and saturation index (SI) indicated the suitability of these samples for different uses. The purpose of the investigations carried by Nives, Š. G.\textsuperscript{126} was to evaluate the influence of the Vrgorska Matica river by using the quality index based on the water quality parameters. Hamadoun, B. et al.\textsuperscript{135} evaluated groundwater quality in Changchun city, Jilin province of China tends to be influenced by human activities. Scatter analyses showed strong positive correlations between $Ca^{2+}$, $Cl^-$ and $NO_3^-$ ions and weak negative correlations between the depth of water table and $Ca^{2+}$, $SO_4^{2-}$, $Cl^-$ and $NO_3^-$ ions. Debels, P. et al.\textsuperscript{147} characterized the spatial and temporal variability of surface water quality using WQI in the Chillán River in Central Chile. Boaventura, G. R. and Freitas A.L. S. D.\textsuperscript{150} discussed the adequacy of traditional ground water investigating parameter pH, EC and TDS. Na, K, Ca, Mg, Fe, Al, Cu, Cd, Cr, Mn, Zn were determined by ICP – AES. Batarseh, M. I.\textsuperscript{154} analyzed for various physiochemical parameters and trace metals content in four provinces in Jordan. Odemis, B. and Evrendilek, F.\textsuperscript{164} assessed water quality and quantity included flow rate, water temperature, pH, EC, SAR, $Na^+$, $K^+$, $Ca^{2+}$, $Mg^{2+}$, $CO_3^{2-}$, $HCO_3^-$, $Cl^-$, $SO_4^{2-}$ in Turkey.

Pathirana, C. and Bandara, N.J.G.J.\textsuperscript{175} investigated the contamination of Maha Oya water by evaluating pH, turbidity, DO, COD, BOD, $PO_4^{3-}$, $NO_3^-$, $SO_4^{2-}$, $Cl^-$, $F^-$, Coliform and heavy metals. Zhou, J. et al.\textsuperscript{201} studied the quality of groundwater in Xinjiang plain area and its direct relationship with human health. Emmanuel, E. O. and Okoh, A. I.\textsuperscript{204} assessed the physicochemical qualities of the final effluents of an urban
wastewater treatment plant in South Africa as well as their impact on the receiving watershed. Tanrıverdi, Ç. et al.\textsuperscript{206} assessed surface water quality of the Ceyhan river basin examined using multivariate statistical techniques to identify characteristics of the water quality in the studied stations. Ashraf, M. A. et al.\textsuperscript{214} analyzed water quality, nutrients and metal load starting from water inlets into the lake basin around Varsity Lake, Kuala Lumpur, Malaysia. Hassan, F. M. et al.\textsuperscript{219} conducted study to reveal possible environmental effects on the Euphrates river Iraq and analysed for physical and chemical properties (air and water temperature, pH, electrical conductivity, TDS, TSS and dissolved oxygen) as well as concentration and distribution of some heavy metals (Cd, Co, Cr, Cu, Fe, Mn, Ni, Pb and Zn) in both dissolved and particulate phases in water. Memon, M. et al.\textsuperscript{220} evaluated the drinking water quality in the Southern Sindh province of Pakistan where drinking water quality is deteriorating due to dumping of industrial and urban waste and use of agrochemicals. Peiyue, Li et al.\textsuperscript{227} identified the chemical characteristics of drinking groundwater and its distribution patterns in Pengyang County, Ningxia, Northwest China. Han, J. G. et al.\textsuperscript{142} analysed the seasonal water pollution based on rainfall feature specially concerned about BOD, heavy metals, nonpoint pollution and sewage discharge at Anyang river basin in Korea. Wei, L. S. et al.\textsuperscript{153} evaluated the water quality during development and apportionment of pollution from rivers in Tapeng Lagoon, Taiwan. Gülbahar, N. and Elhatip, H.\textsuperscript{133} estimated the environmental impacts on the water quality of the Tahtalidam watershed in İzmir, Turkey. Zhu, L. et al.\textsuperscript{233} studied composition, spatial distribution, and environmental significance of water ions in lake Pumayum Co catchment, Southern Tibet for major cations (\(\text{Mg}^{2+}\), \(\text{Ca}^{2+}\), \(\text{Na}^+\) and \(\text{K}^+\)) and anions (\(\text{HCO}_3^-\), \(\text{SO}_4^{2-}\) and \(\text{Cl}^-\)) in the water. Meng, Wei et al.\textsuperscript{195} made an integrated assessment of river health based on water quality, aquatic life and physical habitat. Barros, M.C. et al.\textsuperscript{37} evaluated surface water quality in Portugal during a drought period. Vigna, F. L. et al.\textsuperscript{224} analysed water quality and relationship between superficial and ground water in Rome (Aniene River basin, central Italy).

Bhattacharya, P. et al.\textsuperscript{157} studied Arsenic (As) distribution and toxicology in the environment. Kamau, J. N. et al.\textsuperscript{159} studied seasonal and spatial variation of labile Cu, Fe, Mn, Pb and Zn sediment fractions in lake Naivasha, Kenya. Bubb, J. M. and Lester, J.
N.² had studied the impact of heavy metals on lowland rivers and the implications for man and the environment. **Kiss, T, Osipenko, O.N.**²⁰ had studied toxic effects of heavy metals on ionic channels. **Ronald, F. and Perkins, W.**³ had done routine monitoring of the public water supply in Aberystwyth and revealed high levels of Al with variable Zn content. In a field study of 43 Finnish landfills **Assmuth, T. W. and Strandberg, T.**¹⁹ characterized toxic substances in ground water especially Zn in ground water. **Berg, H. et al.**³⁶ made an attempt to assess the distribution of heavy metals particularly Cr, Cd, Cu, Pb, Mn, Ni, Zn and Se in the lake ecosystem of tropical Lake Kariba, Zimbabwe. **Razo, I. et al.**¹³⁴ studied the the environmental impact of As and heavy metals in Villa de la Paz-Matehuala, San Luis Potosí (Mexico). **Mikulic, N. et al.**¹³⁶ analyzed the fate of heavy metals (Cu, Pb, Zn) in Punat bay on the island of Krk, Northern Adriatic, Croatia. **Sjöblom, Å. et al.**¹³⁷ investigated the changes in metal speciation of As, Ca, Cd, Cu, Fe, Pb, and Zn occurring along the river Vormbäckenhave. **Botté, S. E. et al.**¹⁶⁵ determined the concentration of dissolved Cd, Pb, Cr and Ni in surface water column and pore water, collected from the extensive tidal plain at Bahía Blanca estuary, Argentina. **Dundar, M. S. and Altundag, H.**¹⁶² in their work, collected water samples from three different stations located along the Sakarya river for Pb, Cu, Cr, Zn, Ni and Cd. **Gagneten, A. M. et al.**¹⁶⁶ evaluated levels of heavy metals (Cr, Cu, Pb and Cd) in water of the Lower Salado river, Argentina. **Demirel, Z.**¹⁶⁷ determined heavy metal chiefly Fe, Ni, Mn, Mo and Cu in groundwater from the Mersin aquifer. **Eddy, N. O. and Ekop, A. S.**¹⁷⁰ assessed the quality of water treated and distributed by the Akwa Ibom water company by analyzing samples of water for their physiochemical parameters Temp., pH, EC, Turb., T.Alk., TH, TDS, major ions $^{\text{Fe}^{3+}}$, $^{\text{Na}^{+}}$, $^{\text{K}^{+}}$ nutrients $^{\text{PO}_{4}^{3-}}$, $^{\text{NO}_{3}^{-}}$, $^{\text{SO}_{4}^{2-}}$ and bacteriological quality. **Yalcin, M. G. et al.**¹⁷⁴ investigated the chemical analyses of the water samples and showed Pb, Fe, Cu, Zn, Ni, Cr, Cd, S, F and Cn and ratio of contamination in of Karasu Creek in Nigde, Turkey. **Kumaresan, M. and Riyazuddin, P.**¹⁷⁶ described the interrelationship between major ions, minor ions and trace metal speciation (Cu, Pb, Cd and Zn) collected during the pre-monsoon and post-monsoon seasons by tracing the sources of pollution of groundwater of North Chennai (India). **Tariq, S. R. et al.**¹⁷³ estimated levels of selected metals Na, Ca, Mg, K, Fe, Mn, Cr, Co, Ni, Cd, Pb and Mn in Kasur, a significant industrial city of Pakistan. **Altun, Ö. et al.**¹⁹⁶
analysed physical and chemical parameters viz. temperature, pH, salinity, $PO_{4}^{3-}$, $NO_{3}^{-}$, $SO_{4}^{2-}$, COD and concentrations of heavy metals (Cd, Co, Cr, Cu, Mn, Ni, Pb, Zn) in water samples from a brackish water lagoon, Küçükçekmece, located on the western outskirts of Istanbul. Amin, B. et al.\textsuperscript{200} determined concentrations of Cd, Cu, Pb, Zn, Ni and Fe the surface water in Dumai coastal waters. Chitmanat, C.\textsuperscript{207} investigated heavy metal (Cd, Pb, Zn) contaminants in water, found that the worst water qualities in dry seasons were caused by low water flow, municipal effluents and industrial discharges of the Mae Kuang River, Northern Thailand. Olowu, R. A. et al.\textsuperscript{216} investigated the physiochemical properties of Oke Afa water body. Significant concentration of TSS ranging from (92±100 mg/L), $SO_{4}^{2-}$ (9.84±5.59 mg/L), $PO_{4}^{3-}$ (0.66±0.33 mg/L), $Cl^{-}$ (37±2.84 mg/L), $NO_{3}^{-}$ (2.63±0.6 mg/L) and DO (0.96±0.15 mg/L) were observed. Alves, R.I.D.S. et al.\textsuperscript{221} analyzed the levels of heavy metals mostly Cd, Cr, Cu, Mn, Pb and Zn in surface water of Monte Alegre stream. Sekabira, K. et al.\textsuperscript{222} investigated heavy metal contaminants in the Nakivubo stream water in Kampala, Uganda. Anyakora, C. A.\textsuperscript{19} assessed groundwater in Lagos for their Al, Cd and Pb content. Pansamut, S. and Wattayakorn, G.\textsuperscript{225} determined for arsenic content in water collected from an abandoned Sn mining area at Tambon Ong-pra, in central Thailand. Kaplan, O. et al.\textsuperscript{226} considered the drinking water quality due the pollution and the contamination of groundwater with pollutants of both anthropogenic and natural origin. For these heavy metals concentrations (As, Cu, Cd, Cr, Pb, Ni and Hg) were measured. Liu, H. and Li, W.\textsuperscript{228} analyzed dissolved trace elements and heavy metals of waters and sediments in the ten shallow lakes in the middle and lower reaches of the Yangtze river region to assess the extent of their environmentally detrimental effects. Wang, L. et al.\textsuperscript{229} evaluated dissolved trace metals (Cu, Ni, Fe, Co, Sc, Al, Zn, Pb, Cd, Se, As, Cr, and Hg), major elements(Ca and Mg), and nutrient($NO_{3}^{-}$) on surface water of the Changjiang River. Yalcin, G. M. et al.\textsuperscript{178} determined heavy metal like Pb, Fe, Cu, Zn, Ni, Cr, Cd, S, F and Cn concentrations and the water quality of Karasu Creek in Nigde, Turkey. Queiroz, J. C. B. et al.\textsuperscript{179} studied geochemical characterization of heavy metal contaminated area using multivariate factorial kriging in Amapá State, North Brazil. Akbal, F. et al.\textsuperscript{230} assessed the surface water quality using multivariate statistical techniques for 25 WQP,
total carbon, total inorganic carbon, total organic carbon, Cr, Cd, Cu, Pb, Fe, Ni, Mn, phenol, surfactants, ammonium, nitrite and nitrate-nitrogen, total phosphorus, adsorbable organic halogen, sulfate, TH, DO, pH, temperature, TDS, EC, and salinity of Mid–Black sea coast of Turkey. **Pimentel, H. et al.** studied the water quality in the Ouro Preto region, Minas Gerais, Brazil regarding release of arsenic to the hydrological system. **Bakar, C. et al.** studied the effect of high aluminum concentration in water resources on human health, along Biga Peninsula, northwest part of Turkey. **Momot, O. and Synzynys, B.** studied toxic Al and heavy metals in Groundwater of middle Russia regarding health risk assessment.

**Dojlido, Jan et al.** proposed a new method of a water quality index in the Pilica river in Poland. In the present study **Khan, F. et al.** applied the concept of WQI to three selected watersheds of Atlantic region along the Mersey river, the Point Wolfe river, and the Dunk river sites. **Liou, Shiow-Mey et al.** proposed a better overall index for water quality in Taiwan and its application in Keya River. **Bordalo, A. A. et al.** modified nine-parameter Scottish WQI was used to assess the monthly water quality of the Douro River. **Kannel, P. R. et al.** demonstrated the usefulness of water quality indices, as the indicators of water pollution, for assessment of spatial–temporal changes and classification of river water qualities was verified. **Boyacioglu, H. and Boyacioglu, H.** studied environmetric method which deals with the interpretation of river water monitoring data from the basin of the Buyuk Menderes river and its tributaries in Turkey. **Díaz, J. E. S. and López, E.** assessed spatial and long temporal variations in water quality over the last 25 years with two approaches: the use of a water quality index multiplicative and weighted (WQI) and a principal component analysis (PCA). **Othman, Md. S. et al.** studied water quality changes of Chini Lake for 12 months for 14 water quality parameters and Malaysian Department of Environment Water Quality Index (DOE-WQI) was calculated. **Aloui, B. Z. and Gueddari, M.** investigated long-term water quality of the Sejnane reservoir in Northeast Tunisia including precipitation, evaporation, temperature, pH, EC, DO, turbidity, TSS, major anions and cations, \( F^- \), \( BOD_5 \), \( NO_3^- \), \( NO_2^- \), \( NH_4^+ \), \( P_{tot} \), fecal coliform, bacteria, B and heavy metals (Fe, Zn, Cu, Ni, Pb, Cr and Cd). **Fulazzaky, M. A.** studied water quality degradation in the Brantas' river found that the WQI situates in the very bad class due to increasing of the
wastewater production as well as forests and land degradations resulting from population growth, urbanization and economic and industrial developments. **Yidana, S. M. and Yidana, A.**\(^{199}\) studied the factors viz. Conventional graphical and multivariate statistical methods, playing significant roles in the hydrochemistry of groundwater from the Southern Voltaian formation and WQI, which were in turn used to classify groundwater from the study area. **Saeedi, M. et al.**\(^{203}\) developed a groundwater quality index (GWQI) using multivariate analysis, with the aim of identifying places with best quality for drinking within the Qazvin province, west central of Iran. **Boyacioglu, H.**\(^{205}\) applied the CCMEWQI with modified categorization scheme to assess overall water quality by integrating observed water quality determinants in the Kucuk Menderes Basin, Turkey. **Yue, L. P. et al.**\(^{208}\) assessed the groundwater quality in Pengyang County based on an improved water quality index. For calculating WQI and assess the groundwater quality, total 74 groundwater samples were collected and analyzed for 26 parameters and for computing WQI, 14 parameters were chosen including \(Cl^-, SO_4^{2-}\), pH, COD, TDS, TH, \(NO_3^-, NH_4^+, F^-\), total iron (Tfe), As, I, Al, \(NO_2^-\), metasilicic acid and free carbon dioxide. **Cisneros, B. J.**\(^{46}\) studied water availability index based on quality and quantity and its application in Mexico. **Yakubo, B. B. et al.**\(^{197}\) analysed of groundwater quality using water quality index and conventional graphical methods in the Volta region, Ghana.

2.2 Indian Research Work Done:


Mitra, A. K. analysed water quality of some tributaries of Mahanadi. Samples at five stations in streams Seonath, Jonk and Hasdeo, tributaries of Mahanadi river. The samples were mostly alkaline, low in solute content and contained Ca, Na and Mg as major cations, and $HCO_3^-$, $SO_4^{2-}$, $Cl^-$ as the major anions. Kataria, H. C. determined
Turbidity\textsuperscript{42}, Sulphate\textsuperscript{45}, B.O.D.\textsuperscript{51} and C.O.D.\textsuperscript{51} contents in bore-wells water of Bhopal (MP). Srivastava, G. K. and Singh, B. B.\textsuperscript{34} evaluated physicochemical characteristics of Ami river water. Venkata, M. S. and Reddy, J. S.\textsuperscript{38} assessed the overall water quality of Tirupati. Ahmad, I. and Jain, P.\textsuperscript{49} determined pollution load of Kerwan Dam water at Bhopal during premonsoon season. Singanan, M. and Rao K. S.\textsuperscript{43} analysed ground water of Rameswaram Island. Sawant, C. P. \textit{et al.}\textsuperscript{55} determined metals in well water samples collected from tribal area of Satpura valley by ICP-AES and flamephotometry. Khare, R. \textit{et al.}\textsuperscript{62} studied physico-chemical properties of surface and ground water of major slum areas of New Bhopal (India). Shinde, R. S. \textit{et al.}\textsuperscript{65} studied water quality of river Godavari at Nasik, Maharashtra state India. Bhargava, N. and Sewani, M.\textsuperscript{53} monitored periodic variation in the physico chemical characteristics of river Chambal at Kota. Amlan, S. V and Pillai, K. S.\textsuperscript{67} studied dental fluorosis in an industrial area contaminated with fluoride in drinking water. Gambhi, S. K.\textsuperscript{69} investigated physio-chemical and biological characteristics of water of Maithon Reservoir of D.V.C. Jain, P. K.\textsuperscript{70} assessed water quality of Khnop reservoir in Chhatarpur, MP India. Pillai, A. \textit{et al.}\textsuperscript{74} monitored physico-chemical characteristics of drinking water of Durg Municipality. Sharma B. S. and Agarwal, A.\textsuperscript{75} assessed water quality of river Yamuna at Agra. Sivakumar, R. \textit{et al.}\textsuperscript{86} undertaken physio chemical analysis of water sources of Ooty, South India. Dahiya, S. and Kaur, A.\textsuperscript{80} determined physico – chemical characteristics of underground water in rural areas of Tosham subdivisions, Bhiwani district, Haryana. Majumdar, D. and Gupta, N.\textsuperscript{87} studied nitrate pollution in groundwater and associated human health disorders. Nagarajan, P. and Priya, G. K.\textsuperscript{82} monitored the deterioration of Ground water quality in Tiruchirapalli, Tamil Nadu. Sharma, B.S.\textsuperscript{83} studied the physico-chemical characteristics of Yamuna water at Agra in order to ascertain the viability of the water for domestic use. Gupta, S. C. \textit{et al.}\textsuperscript{97} studied hydrochemistry of Udaipur Lakes. Koshy, M. and Vasudevan, N. T.\textsuperscript{91} analysed physio – chemical water quality of river Pamba at Kozhencherry for three years. Ramesh, H. S. and Mahender, B.\textsuperscript{94} investigated subsurface water quality Kalayarkoil Union of Tamil Nadu for premonsoon and postmonsoon seasons. Khwaja, A. R. \textit{et al.}\textsuperscript{100} monitored Ganga water due to tannery pollution at Kanpur (India). Biswal, S. K. \textit{et al.}\textsuperscript{103} monitored groundwater quality near ash pond of thermal power plant for pre-monsoon and post-monsoon period.
Reghunath, R. et al.\textsuperscript{107} determined spatial distribution of pH, EC and TDS of groundwater of Nethravathi river basin, Karnataka State, India.

Sharma, S. K. et al.\textsuperscript{108} studied impact of industrial pollution on ground water quality in Kalmeshwar area, Nagpur district, Maharashtra. Biswal, S. K. et al.\textsuperscript{106} investigated effect of thermal power plant ash pond on ground water. Madhavi, A. and Rao, P. A.\textsuperscript{119} monitored effect of industrial effluent on properties of groundwater in four major industrial areas of Hyderabad, Andhra Pradesh. Study revealed the aggravated acidity, EC, TDS, COD, $Cl^-$, $SO_4^{2-}$, $PO_4^{3-}$, $NO_3^-$, $F^-$. Ahmad, A. and Alam, M.\textsuperscript{121} undertaken physico-chemical and toxicological studies of industrial effluents in and around Delhi and ground water quality of some areas in Delhi city. Chatterjee, P. et al.\textsuperscript{122} analysed physico-chemical parameters of Loco tank, a reservoir in Asansol town, West Bengal. Ravichandran, S.\textsuperscript{129} studied hydrological influences on the water quality trends in Tamiraparani basin, south India. Sivakumar, A. A. et al.\textsuperscript{130} studied on water quality like including TSS, TDS and EC and chemical qualities including the study of pH, $CO_3^{2-}$, $HCO_3^-$, alkalinity, etc of the river Ambarampalayam, Coimbatore district, Tamil Nadu. Bhadra, B. et al.\textsuperscript{138} investigated some basic water quality parameters of the north Bengal Terai river Kaljani, a tributary of river Torsa. Kumar, D. et al.\textsuperscript{144} determined physico-chemical characteristics of Amanishah Nallah and neighbouring ground water sources in Sanganer, Jaipur. Thilaga, A. et al.\textsuperscript{146} studied nutrient content of the Ooty lake with reference to pollution. Singh, A. K. et al.\textsuperscript{177} analysed for pH, EC, TDS, $F^-$, $Cl^-$, $HCO_3^-$, $SO_4^{2-}$, $NO_3^-$, $Ca^+$, $Mg^+$, $Na^+$ and $K^+$ in water of Damodar River Basin, India. Purkait, S. et al.\textsuperscript{193} assessed the impact of various pollutant in water of Ganga in Kolkata with special reference to quality evaluation and environmental implication. Gupta, A. et al.\textsuperscript{194} analysed some heavy metals in river Ganga at Allahabad and located the metals concentration in order Zn $>$ Pb $>$ Cu $>$ Cr $>$ Cd. Suthar, S.\textsuperscript{231} determined the contamination of drinking water and its perspectives on rural health in Rajasthan, India. Chetia, M. et al.\textsuperscript{234} studied the contamination of ground water with arsenic along with Fe, Mn, Ca, Na, K, and Mg with pH, TH, and $SO_4^{2-}$ in Brahmaputra river basin, in Golaghat (Assam). Chandra, R. et al.\textsuperscript{211} monitored water quality in the wetlands of Coimbatore, Tamil Nadu, India. Solaraj, G. et al.\textsuperscript{215} analysed the water
quality in selected region of Cauvery Delta river basin with emphasis of monsoonal variation. **Jameel, A. A. and Hussain, Z. A.**\(^{237}\) monitored the quality of groundwater on the bank of Uyyakonkan channel of river Cauvery at Trichirappalli, Tamil Nadu, India. **Jindal, R. and Sharma, C.**\(^{238}\) studied the quality of water in Sutlej river around Ludhiana city with emphasis on physico–chemical parameters.

**Patel, K. S. et al.**\(^{139}\) had investigated arsenic in contaminated water. **Lokeshwari, H. and Chandrappa, G. T.**\(^{158}\) had studied effects of heavy metal contamination from anthropogenic sources on Dasarahalli tank, India. **Dixit R. C. et al.**\(^{116}\) has studied heavy metal contamination in surface and ground water supply of an urban city. **Wahid, I. A. et al.**\(^{1}\) studied pollution by heavy metal like Fe, Cu, Zn, Ni, Co, Pb and Cd in western Uttar Pradesh. **Hegde, S. N. and Puranik, S. C.**\(^{15}\) studied for Fe, Mn, Cu, Ni, Pb and Cd in groundwaters of Hubli city, Karnataka, India. **Krishnamurthy, S. R. and Bharati, S. G.** showed the distribution of iron\(^{21}\), manganese\(^{39}\), Zinc\(^{40}\) in the surface waters and investigated the toxic metal\(^{26}\) (Pb, Ni, Cd, Co, Ch, Cu) of the polluted river Kali, around Dandeii, (North Kanara District), Karnataka, India. **Patel, M. K. and Patel, T. K.**\(^{18}\) assessed water quality in the river Sankh of western Orissa for TS, Fe and Cd in excess. **Gautam, A. and Sati, O. P.**\(^{25}\) analysed concentration of eight metals viz. Pb, Zn, Mn, Fe, Co, Mg, Cu, and Ca in the water of river Bhagirathi. **Pervez, S. and Pandey, G. S.**\(^{27}\) studied variations in rain water characteristics in areas around steel plant at Bilai, results in higher concentration of Ca, Mg and Na. **Venkateswarlu, V. et al.**\(^{30}\) examined heavy metal pollution in the rivers of Andira Pradesh, India. **Mishra, A. et al.**\(^{29}\) assessed heavy metal like Cu, Zn, Pb, Fe, Cr, and Cd for pollution of river Subarnarekha in Bihar. **Venkata Reddy, M. and Singh, G.**\(^{32}\) assessed heavy metals concentration levels from groundwater of Dhanbad city in highly industrialised Jharia coalfield. **Meenakumari, B. and Nair, N. B.**\(^{47}\) studied the concentration of Cu, Fe, Mn, Zn, Co, Ni, Cd and Pb present in the Cochin harbour waters and were studied at monthly intervals. **Baruah, N. K. et al.**\(^{50}\) studied the distribution of heavy metals Cu, Cd, Zn, Pb, Ni, Co, Cr, Fe, Mn and Hg in river Jhangi. **Senapati, N. K. and Sahu, K. C.**\(^{56}\) analyzed for the estimation of the natural and anthropogenic heavy metal fluxes from Subarnarekha river. **Shivkumar, K. et al.**\(^{57}\) determined toxic trace element pollution in ground waters around Patancheru and Bolaram industrial areas, Andhra Pradesh, India. **Dwivedi, S. and Tewari, I. C.**\(^{60}\)
studied seasonal variation in heavy metal namely Cu, Cd, Cr, Fe and Pb of river Ganga at Varnasi. Khurshid, S. et al.\textsuperscript{63} showed degradation of water quality due to heavy metal pollution in Faridabad district, Haryana, India. Kumar, V. et al.\textsuperscript{64} evaluated pollution status of aquatic system of central part of Jharia coalfield with special reference to heavy metal. Results indicated the presence of Cd, Pb, Fe, As and Se in levels higher than the limits prescribed by Bureau of Indian Standard (BIS) for drinking water (IS: 10500). Pande, N. and Singh, B.C.\textsuperscript{54} determined trace metals (Fe, Mn, Zn, Cu, C1; Pb, As and Hg) in drinking water from different sources in port city of Paradeep. Mehrotra, P. and Mehrotra, S.\textsuperscript{71} investigated pollution of ground water by Mn in Hindon-Yamuna doab (NOIDA area), Dist Gaziabad. Mohapatra, U.K. and Singh, B.C.\textsuperscript{72} identified trace metals in drinking water form different sources in the old capital city of Cuttack. Sawant, C. P. et al.\textsuperscript{85} determined trace metals in and around an industrial belt. Chauhan, B. S. et al.\textsuperscript{79} monitored seasonal concentrations and speciation of heavy metals in groundwater of Agra city. Govindasamy, C. and Azariah, J.\textsuperscript{81} studied seasonal variation of heavy metals in coastal water of the Coromandal coast, Bay of Bengal, reported high values of Cu, Cd, Zn, Ni, Co and Hg. Kaushik, A. et al.\textsuperscript{90} determined concentration of heavy metals like Fe, Co and Cd in the water of river Ghaggar all along its route in Haryana. Saha, S. B. et al.\textsuperscript{77} showed heavy metal pollution in Jagannath canal, an important tidal water body of the north Sundarbans aquatic ecosystem of West Bengal. The magnitude of different trace metals followed the hierarchy Fe>Zn>Mn>Cu>Pb>Cd. Mule, M. B. and Patil, R. K.\textsuperscript{102} studied metal contents such as Fe, Co, Ni, Mn, Pb, Zn and Cu in water resources from Radhanagari forest. Bhosle, A. B.\textsuperscript{117} studied Fe content in the river Godavari at Nanded and its impact on river ecology. Gupta, A. K. and Raghubanshi, A. K.\textsuperscript{111} made a comparative study of enrichment of nutrients and heavy metals in river waters Ghaghra and Ganga due to anthropogenic pressures. Manimaran, B. et al.\textsuperscript{113} indicated metal pollution in Tuticorin coastal waters due to fly ash of thermal power plants. The relative concentration of four heavy metals could be arranged as Al<Fe<Zn<Cu. Srivastava, N. et al.\textsuperscript{120} studied physico-chemical characteristics of water bodies around Jaipur. Dixit, R. C., et al.\textsuperscript{123} identified heavy metals contamination in surface and groundwater supply of an urban city presented levels of Mn, Cu, Se and Cd were found marginally above the Indian Standards (IS) specification regulated for
drinking water. Srivastava, A. K.\textsuperscript{131} made a study on effects of toxic elements in Gomti river at Jaunpur. Puthiyasekar, C. et al.\textsuperscript{210} studied the contamination of heavy metals in bore water due to industrial pollution emphasizing the metal speciation Na, Mg, Al, K, Ca, Cu, Cd, Hg and Pb in Thootikudi and Tirunelveli of south Tamil Nadu, India. Aktar, Md. W. et al.\textsuperscript{213} assessed various heavy metals viz. Fe, Mn, Cu, Zn, Pb, Cd, Cr, and Ni) of surface water at four different locations of the river Ganga around Kolkata and investigated its toxicity and ecological perspectives. Bhagure, G. R. and Mirgane, S. R.\textsuperscript{232} determined the concentration of heavy metals in ground water of Thane region of Maharashtra India. High concentration of TDS, TH, TA, COD are indicated with As, Cd, Hg and Ni. using ICP – AES.

Sahu, B. K., et al.\textsuperscript{9} calculated Water quality index of the river Brahmani at Rourkela industrial complex of Orissa. Singh, D. F.\textsuperscript{12} studied on the water quality index of some major rivers of Pune, Maharashtra. Sinha, A. K.\textsuperscript{31} studied Water quality index for river Sai at Rae Bareli. Singh, R. K. and Anandh, H.\textsuperscript{48} worked out water quality indices for some Indian rivers based on published data of Central Pollution Control Board, New Delhi. Pande, K. S. and Sharma, S. D.\textsuperscript{73} demonstrated, water quality index for Ramganga river at Moradabad, Uttar Pradesh in their reseach paper. Singh, A. P. and Ghosh, S. K.\textsuperscript{78} showed water quality index for river Yamuna. Mohanta, B. K and Patra, A. K.\textsuperscript{93} studied on the water quality index of river Sanamachhakandana at Keonjhar Garh, Orissa, India. Kaur, H. et al.\textsuperscript{99} determined water quality index of the river Satluj. Mishra, P.C. and Patel, R. K.\textsuperscript{101} identified quality of drinking water in Rourkela, outside the steel township using WQI by taking twelve parameters. Yazdandoost, M. Y. and Katdare, M. S.\textsuperscript{96} showed water quality index of major rivers in Pune. Chatterjee, C. and Raziuddin, M.\textsuperscript{110} determined Water Quality Index (WQI) of a degraded river in Asansol industrial area (West Bengal). Kaushik, A. et al.\textsuperscript{112} assessed water quality index and suitability of urban ground water of Hisar and Panipat in Haryana. Kumar A. and Shukla M.\textsuperscript{115} again calculated water Quality Index (WQI) of river Sai water at Raebareli city, U.P. Guru Prasad, B.\textsuperscript{128} evaluation of water quality in Tadepalli mandal of Guntur district, A.P. with aimed to calculate Water Quality Index (WQI) of ground water and to assess the impact of pollutants due to agriculture and human activities on its quality. Ramesh, S. et al.\textsuperscript{212} made an innovative approach of
drining water quality index – Southern Tamil Nadu, India. Avvannavar, S. M. and Shrihari, S.\(^\text{187}\) evaluated water quality index for drinking purposes for river Netravathi, Mangalore, South India. Vasanthavigar, M. et al.\(^\text{223}\) demonstrated the application of WQI for ground water quality assessment in Thirumanimuttar sub-basin, Tamilnadu, India. Srivastava, P. K. et al.\(^\text{217}\) characterized the monsoonal variation on Water Quality Index of river Mahi in India. Chaturvedi, M. K. and Bassin, J. K.\(^\text{218}\) assessed WQI of Water treatment plant and bore wells in Delhi, India. Puri, P. J. et al.\(^\text{239}\) had assessed WQI of surface water in Nagpur city.

Ghandrashekar, M. et al.\(^\text{5}\) made statistical studies on the correlation of dissolved oxygen levels with environmental factors in Amaravathi river (South India). Patel, M. K.\(^\text{16}\) showed correlations among seven trace metals, namely Mn, Fe, Ni, Cu, Zn, Cd and Pb in the coastal waters of Visakhapatnam. Somasekhara Rao, K. and Someswara Rao, B.\(^\text{28}\) had done the systematic calculation of the correlation coefficients, \(r\), among water quality parameters of ground waters of Musunur Mandal, Krishna district. Singh, S. K. and Kumar, P. S.\(^\text{33}\) carried out correlation among different physicochemical parameters of groundwater in Karimnagar district (Andhra Pradesh). Ravi, V. et al.\(^\text{52}\) studied water potability using multivariate statistical models. Chandrasekaran, G. E. and Muthu Kumar, M.\(^\text{58}\) statistically analyzed parameters of river waters of Tikara and river Brahmani near the proposed super Thermal power plant site at Talcher. Dhembare, A. J. and Pondhe, G. M.\(^\text{59}\) correlated ground water quality parameters of sonai area (Maharastra). High correlation coefficient was observed in between EC-TDS, TDS-\(\text{HCO}_3^-\), Mg Cl and \(\text{HCO}_3^-\), RSC. Gupta, A. K. and Saxena, G. C.\(^\text{61}\) had done correlation studies among various water quality parameters in ground waters of different urban industrial zones of Agra. Somasekhar, R. K. et al.\(^\text{88}\) evaluated ground water chemistry of Channapatana taluk (Bangalore rural district) using regression and cluster analysis. Sulochana, N. et al.\(^\text{76}\) undertaken monitoring, correlation and possibilities of contamination of ground water in Thuvakudi village, Tiruchirapalli district. Jain, C. K. and Sharma, M. K.\(^\text{89}\) had done regression analysis of ground water quality data of Sagar district, Madhya Pradesh. Mariappan, P. et al.\(^\text{92}\) established correlation between water table level and fluoride content in the groundwaters of Salem district, Tamil Nadu. Rath, P. et al.\(^\text{95}\) showed multivariate statistical approach to study physico-chemical
characteristics in Nandira-Brahmani river, Angul-Talcher belt, Orissa, India. Dasgupta, A. M. and Purohit, K. M.\textsuperscript{98} determined status of surfaces and ground water quality of Mandiakudar by means of correlation coefficient and regression equations. Mohapatra, D. et al.\textsuperscript{104} made a correlation study on physico chemical characteristics of ground water in Paradip areas. Mariappan, P. and Vasudevan, T.\textsuperscript{114} investigated correlation coefficients of some physico-chemical parameters of drinking water ponds in eastern part of Sivagangai district, Tamil Nadu. Nageswara Rao, V. V. and Prapurna, N.\textsuperscript{145} made statistical analysis of ground water quality parameters in an industrial area of Hyderabad. Rajankar P. N. et al.\textsuperscript{240} had studied the seasonal variation in groundwater quality of Yavatmal District, India.

2.3. Noteworthy Contribution:

Sridhar, R.\textsuperscript{44} undertaken chemical characteristics of the groundwater in parts of Dharsiwa block, Raipur district, Chhattisgarh. Sharma, S.\textsuperscript{124} studied toxic elements due to industrialisation in soil, water, plants and fish. Verma, S. and Khan, S.A.\textsuperscript{161} studied quality of water in the Arpa river of Bilaspur District (C.G.). Shrivastava, B. K. and Alam, M.\textsuperscript{152} assessed ground-water quality of Raigarh city in Chhattisgarh state for drinking water purpose based on physico-chemicals, heavy metals and bacteriological (Coliform) parameters. Kamavisdar, A. and Patel, R. M.\textsuperscript{183} made a study on Pb, Fe and Hg in water samples near metalloferrous mining industries of Chhattisgarh State, Central India. Krishnamurthy, S.\textsuperscript{118} undertaken physico-chemical studies of water of Bilaspur city and its suburbs. Shrivastava, S. K. et al.\textsuperscript{180} statistically analyzed water quality of different pond in Bilaspur (C.G.) and determine the correlation between various water quality parameters. Kaur, P.\textsuperscript{181} studied Total solids occurring in various industries effluent water present in Durg district (C.G.). Verma, S.\textsuperscript{191} examined water of Bilaspur city with special reference to pollution due to heavy population and industrialization. Sinha, D.\textsuperscript{140} analyzed chemicals present in soil, water, plant and aquatic animals with special reference to industrial effluents and pollution effects in Bilaspur District (C.G.). Shastri, G. N. and Singh, N.K.\textsuperscript{190} had done chemical analysis of water from different ponds of Newara village of Bilaspur (C.G.) India. Dewangan, H. S.\textsuperscript{185} studied toxic elements eg \(Pb^{2+}\) and \(Cd^{2+}\) in the soil, water, plant and fishes in Janjgir-Champa district.
of Chhattisgarh State. Madhuri, N.\textsuperscript{151} emphasized the impact of industrial pollution in Arpa river water with a special reference to physico chemical studies. 

Aggarwal, S. G, et al.\textsuperscript{105} studied acidification of surface water in central India. Most of the rain and fog water samples collected from Bikunthpur and Korba sites were found to be acidic in nature. Nayar, R. and Tiwari, D.\textsuperscript{184} studied the physicochemical characteristics of ground water of Korba city, chhattisgarh, India. Singh, D. et al.\textsuperscript{182} investigated water quality parameters, $Pb^{2+}$ and $Cd^{2+}$ concentration distribution in Hasdeo river in Korba (C.G.). Sahu, R. K.\textsuperscript{127} examined toxic Elements in coal, coal ash, soil, water and plants of Dipika coal area, Korba. Tripathi, N. K.\textsuperscript{143} enumerated environmental problems due to flyash dispersion in the Korba district of Chhattisgarh state. Nayar, R.\textsuperscript{156} investigated physicochemical properties of underground drinking water of korba and its surrounding industrial areas. Upadhaya, M.\textsuperscript{73} had studied physico chemical studies of effluent from Korba industrial area. Vaishnav, M.M. and Sahu, A.\textsuperscript{149} had studied fluoride content in Korba - Balco area. Vaishnav, M.M. and Sahu, D.\textsuperscript{48} had analyzed water of Hasdeo River in Korba.

2.4 References


143. Tripathi, N. K.; *Environmental problems due to flyash dispersion in the Korba district of Chhattisgarh state*, Ph.d Thesis submitted in Guru Ghasidas University, 2005


191. Verma, S.; *Water Analysis of Bilaspur City With Special Reference to Pollution Due to Heavy Population & Industrialisation*, Ph.d Thesis submitted in Guru Ghasidas University, 2009


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