REDVET - Revista electrónica de Veterinaria - ISSN 1695-7504
Vol 25, No. 1S (2024)
http://www.veterinaria.org
Article Received: 02 June 2024 Revised: 08 June 2024 Accepted: 15 June 2024

Physico-Chemical Analysis of Wastewater Discharge from Various Industries of Jaipur

Sunita[1*], Pooran Mal[2], Mala Mathur[3], Yogesh Kumar[4],

[1*]Department of Chemistry, Vivekananda Global University Jaipur (Rajasthan)
[2]Department of Chemistry, Vivekananda Global University Jaipur (Rajasthan)
[3]Department of Chemistry, Vivekananda Global University, Jaipur, Rajasthan
[4]S.B.R.M. Govt. College Nagaur (Rajasthan)

Abstract
Wastewater management is an important component of the 'water resources management system' that must be sustainable in terms of environmental impacts and service provision costs. In India, poor water sanitation as well as hygiene account for approximately 7.5% of all mortality. Treating the wastewater for such uses as gardening and industrial use will help save potable water, which is vital in areas like Rajasthan where the main source of water is groundwater. The city has an adequate number of 'sewage treatment plants (STPs)' to treat the quantum of wastewater produced. This article seeks to assess the current systems that are in place to deal with water scarcity and postulates that a sustainable solution can only come with a multi-disciplinary approach that considers the socio-political factors that lead to the pollution of water.

Keywords: Wastewater, Jaipur, Industry, Physico chemical, Industries, industrial effluents, Pollution.

Introduction
Over the last two centuries, the 'Industrial Revolution' has brought about considerable development in India but at the same time, it has posed severe environmental problems of which water pollution due to industrial effluents is one of the most alarming. Science and technology have advanced, and this has enhanced the growth of heavy industries which has led to industrial pollution. During industrial operation, water gets contaminated with chemicals, heavy metals, inorganic wastes, and organic sludge [1]. These pollutants are often released to the rivers and other water courses, thus causing significant build-up of industrial effluents. This pollution affects the quality of the environment and affects human beings, plants, and animals.

Several important factors determine industrial development, and the most significant of them are the availability of the labor force and natural resources. Uttar Pradesh is also blessed with coal, dolomite, gems, diaspore, sulfur, magnesite, pyrophyllite, silica, sand limestone, etc, and has experienced rapid industrialization.

Like any other city in the world, Rajasthan also has its issues with the disposal of greywater, blackwater, and fecal sludge. Over the last few years, the Rajasthan government has extended more funds to centralized sanitation projects with the help of central government grants and the Asian Development Bank loans. These centralized sanitation systems are mainly in towns with a population of over 500,000 people, but projects are being carried out in other towns within the state [3].
Rajasthan is predominantly a desert area with 60% of the area being a desert and 40% being semi-desert. The desert area gets less than 400 mm of rainfall per year while the semi-desert area gets between 550 mm and 800 mm of rainfall per year annual precipitation in much of the state is inadequate even in the absence of a meteorological drought declaration hence there is continuous agricultural drought. 'The western part of the Aravalli range has been receiving a lesser amount of rainfall and is now the driest region in the state of Rajasthan. Annual precipitation in the state is 490 mm with variation at the district level ranging from 100 mm in the northwest region of Jaisalmer to over 1000 mm in Jhalawar. About 85% of this amount of rainfall is received during the southwest monsoon while the rest is during winter through western disturbances' [4].

Jaipur, the capital city of Rajasthan, is one of the most developing cities of India where the rate of urbanization as well as industrialization is very high. This growth has placed a lot of pressure on the available groundwater resources hence a harmful effect on the condition of the groundwater [5].

Impact of industrial effluents on human health
Industrial effluents are the main contributors to water pollution, discharging different pollutants in the water either directly from industrial outfalls or indirectly through sewage. These pollutants are dangerous to human health in the following ways. Industrial water effluents are usually characterized by high concentrations of organic compounds and heavy metals including pesticides, PCBs, dioxins, PAHs, petrochemicals, and phenolic compounds. When such substances are discharged directly into water bodies, they are likely to have harmful effects on water quality, human health, and aquatic life [6]. Some of the heavy metals include 'chromium (Cr), lead (Pb), mercury (Hg), nickel (Ni), copper (Cu), zinc (Zn),

REDVET - Revista electrónica de Veterinaria - ISSN 1695-7504
Vol 25, No. 1S (2024)
http://www.veterinaria.org
Article Received: 02 June 2024 Revised: 08 June 2024 Accepted: 15 June 2024

arsenic (As), and cadmium (Cd)' that may cause biomagnification in the food chain when they are released in water systems. Studies in toxicology have improved the knowledge of the toxic impact of heavy metals which can lead to developmental problems, cancer, kidney diseases, hormonal imbalances, immune system disorders including autoimmunity, and sometimes death.

Sources of pollution
Pollutants typically originate from three primary sources:
1. Sewage released into rivers.
2. Industrial waste is not treated before they are discharged into rivers.
3. Water from the fields which may contain chemical fertilizers, pesticides, insecticides, and manure that runs over the surface of the soil.

Characteristics of wastewater
Water can be of different types depending on the source of water. However, if the industrial wastewater is like municipal or domestic wastewater, then it may need some form of pre-treatment if it is combined with the latter. As mentioned earlier, wastewater produced by different industries has different properties and therefore it needs to be treated specially [7].

- **Physical Properties:**
  - 'Electrical Conductivity (EC)': About the amount of salt in water.
  - 'Total Dissolved Solids (TDS)': It denotes inorganic minerals and tiny quantities of biological materials dissolved in water.
  - 'Suspended Solids (SS)': Pertains to the solid particles which do not dissolve in water but are suspended in it as small lumps.
- **Chemical Properties:**
  - 'Dissolved Oxygen (DO)': Helps in setting the level of dissolved oxygen in water.
  - 'Biochemical Oxygen Demand (BOD)': Denotes the quantity of oxygen that aerobic bacteria require to break down organic materials in a water sample in each time.
  - 'Chemical Oxygen Demand (COD)': Represents the oxygen equivalent needed to oxidize the organic matter in a sample using a strong chemical oxidant.
  - 'Total Organic Carbon (TOC)': It defines the total amount of carbon in each sample that is organic.
  - 'Ammonium (NH4-N) and Nitrate (NO3-N)': Display forms of soluble nitrogen in the water.
  - 'Total Kjeldahl Nitrogen (TKN)': Defines organically bound ammonia nitrogen.
  - 'Total Phosphorus (Total-P)': This is an abbreviation of total phosphorus which is the total amount of phosphorus in a sample.
- **Biological Properties:**
  - 'Total Coliforms (TC)': A broad indicator of water pollution that may contain fecal coliforms and other ordinary soil bacteria.
  - 'Fecal Coliforms (FC)': Refers to contamination with fecal matter and the most frequent ones are Escherichia coli (E. coli).
  - Helminth Analysis: It is used in the detection of worm eggs in water.

Review of Literature
Grover et al. (1988) [8] explored the physicochemical properties of the Sone River, while Chatterjee et al. (1981) [9] researched the biotic structure of Aligarh's Kali River. Badola and Singh did an equal investigation on the Alaknanda River in 1981 [10]. Furthermore, Nair et al. (1989) [11] studied the Neyyar River, while Deshmukh et al. (1984) [12] investigated Nagpur's Kanhan River. All of these rivers were found to be contaminated, which is concerning, particularly in India, where rivers are revered.

Mahdi et al. [13] have investigated the levels of serum lipids in 2007. designed a system of anaerobic-aerobic treatment for textile wastewater. The textile sector is one of the biggest users of water and most of the water is used during the dyeing and finishing stages. Due to the high flow rate and concentration of contaminants, textile industry wastewater is considered one of the most polluting. The study used a continuous-flow combined anaerobic-aerobic reactor for treatment with microbial growth media in the anaerobic reactor being Cosmo balls. The study evaluated the impact of changes in pH, DO, and organic on the rates of nitrification and denitrification. Findings showed that the system had the potential to remove ammonia nitrogen by 84. 62% and volatile suspended solid (VSS) by 98. 9%. Nitrification was not significantly influenced by changes in pH and dissolved oxygen; a 3% change in pH was equivalent to a 10% reduction in nitrogen.
'Fayza et al. (2004) [14] studied the removal of pollutants in chemical industrial wastewater from building and construction chemical factories and plastic shoe manufacturing plants. These wastewaters were directly discharged to the

REDVET - Revista electrónica de Veterinaria - ISSN 1695-7504
Vol 25, No. 1S (2024)
http://www.veterinaria.org
Article Received: 02 June 2024 Revised: 08 June 2024 Accepted: 15 June 2024

public sewers from these facilities. The wastewater generated from the building and construction chemicals factory was characterized by high concentrations of organic pollutants with average COD and BOD values of 2912 and 150 mgO2/l respectively and phenol concentration of up to 0. 3 mg/l. Lime and ferric chloride treatments were proved to be efficient in generating effluent that complied with the Egyptian standards. At the plastic shoe factory, wastewater was diluted with domestic wastewater to reduce the organic load where the COD and BOD values were 5239 and 2615 mgO2/l respectively, and the average phenol concentration of 0. 5 mg/l'.

There has been a lot of improvement in the treatment of wastewater to become potable water. More recently, there have been requirements for a minimum level of treatment before discharge no matter the size of the water body that is to receive the effluent (Peavy, Rowe, & Tchobanoglous, 1985) [15]. The attention is now being directed to DEWATS, especially in developing countries such as Ghana where centralized wastewater management is poor and challenging (Adu-Ahyia & Anku, 2010) [16].

Traditional wastewater treatment technologies include activated sludge, trickling filters, and rotating biological contactors, all of which have downsides. Trickling filters and rotating biological contactors are temperature sensitive and have lower BOD removal effectiveness. Additionally, trickling filters are more expensive to build than activated sludge systems. Activated sludge systems, while efficient, are expensive due to the energy needed for pumping and aeration (NPTEL, 2010) [17].

Objectives
- Study the physical and chemical quality of the groundwater available in Jaipur city.
- Research on the unit operations and processes that are used in the treatment of wastewater.
- Examine the operations of Wastewater Treatment Plants.
- Evaluate the physical and chemical characteristics of water and the content of heavy metals.

Research Methodology
This research used interviews, observation, and documents as research instruments to collect qualitative data. Unlike quantitative research which is concerned with cause and effect, qualitative research seeks to explain a situation or phenomenon by telling a story. Secondary sources required analytical and descriptive methods, and that meant a detailed examination and a proper evaluation of secondary sources were necessary. To complement the textual analysis, it was important to get more opinions, which required a very careful reading of the chosen secondary sources. These secondary sources were important for the close reading and analysis that was necessary for applying the research's analytical and descriptive methods.

Result and Discussion
Table 1 shows the permissible concentrations of the physicochemical characteristics and heavy metals in water for the sustenance of aquatic life. This is especially so since more than 95% of industries are found along water bodies such as rivers and other water sources [18]. The table also shows the upper and lower limits of these parameters and contaminants that are permissible.

S No.	Parameters	Unit	Minimum permissible limit	Maximum permissible limit
1.	pH		6.5	8.5
2.	Conductivity	μS cm^{-1}	200	1000
3.	Turbidity	NTU	1	5
4.	Colour	TCU	5	15
5.	Total Dissolve Solid	mg L^{-1}	200	600
6.	Dissolved Oxygen	mg L^{-1}	3.5	5.0
7.	Hardness	mg L^{-1}	220	600
8.	Nitrate	mg L^{-1}	-	45
9.	Sulphate	mg L^{-1}	200	400
10.	Phosphate	mg L^{-1}	-	5
11.	Chloride	mg L^{-1}	250	1000
12.	Alkalinity	mg L^{-1}	200	600
13.	Total Ammonia	mg L^{-1}	-	0.5
14.	Mercury	mg L^{-1}	-	0.001
15.	Arsenic	mg L^{-1}	-	0.01
16.	Cadmium	mg L^{-1}	-	0.003
17.	Lead	mg L^{-1}	-	0.001
18.	Iron	mg L^{-1}	-	0.01
19.	Copper	mg L^{-1}	-	1.0
20.	Chromium	mg L^{-1}	-	0.05

REDVET - Revista electrónica de Veterinaria - ISSN 1695-7504
Vol 25, No. 1S (2024)
http://www.veterinaria.org
Article Received: 02 June 2024 Revised: 08 June 2024 Accepted: 15 June 2024

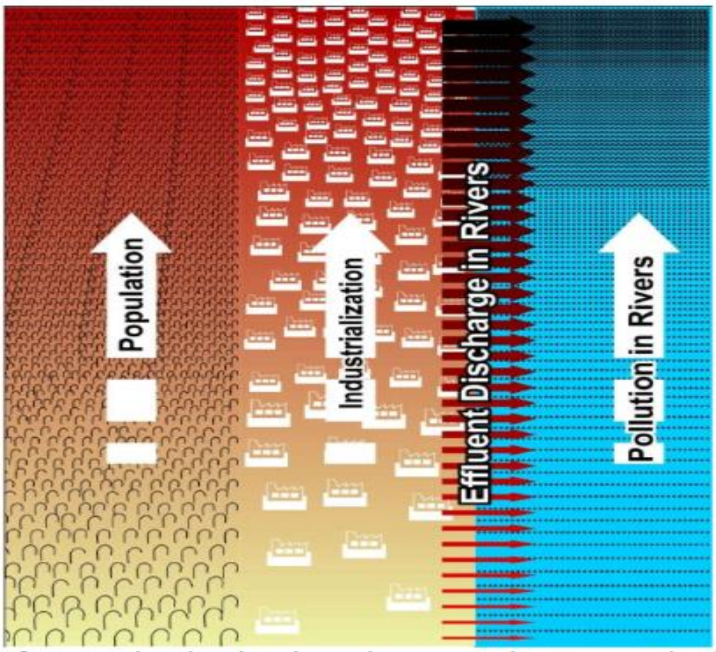
As the level of industrialization and population density rises, the levels of contamination in the rivers also rise as depicted in Figure 1. This trend shows the influence of population and industrialization on the pollution of rivers [19].
'The collected samples were analyzed for temperature, pH, TSS, TDS, TSS, DO, BOD, COD, dissolved CO2, alkalinity, and hardness. The methods used in sample collection, storage, analysis, and interpretation were by Rainwater and Thatcher (1960) and E. Brown (1970)'.

Table 2 gives the physicochemical characteristics of the effluent samples collected from the industrial area of Jaipur, Rajasthan.

S. No.	Parameters	Site 1 Industrial Area 22 GODAM Electrical Industry	Site 2 Engineering Industry VKI area	Site 3 Paper Industry Sanganer	Site 4 Dye Industry Sanganer
1.	PH	7.20±0.002	7.04±0.02	8.44±0.02	8.50±0.02
2.	Temp °c	29.4	34.8	32.3	30.4
3.	EC $_{s/m}$	78.6	51.2	33.6	98.7
4.	DO $_{mg/lit}$	4	2	2	0
5.	BOD $_{mg/lit}$	225	590	84	186
6.	COD $_{mg/lit}$	703	1811.7	262	649.8
7.	Alkalinity $_{mg/lit}$	715.5	397.5	450	371
8.	Hardness $_{ppm}$	880	620	930	880
9.	TS $_{mg/lit}$	273	190	202	315
10.	TDS $_{mg/lit}$	150	155	120	250
11.	TSS $_{mg/lit}$	123	96	75	65

'Table 2 shows the experimental data of the physicochemical characteristics of water samples collected from different industrial zones of Jaipur.

The temperature of wastewater from industrial zones can affect the quality of soil if it is directly discharged on the land, it may boost microbial action and decrease the fertility of the soil [20]. Also, the disposal of wastewater directly to water bodies can hurt the water organisms. The temperature of the samples was within the range of 29. 4°C and 34. 8°C.
pH is the measure of the acidity or alkalinity of water and since wastewater treatment involves the removal of toxic metals, the pH of water needs to be altered. The pH values of all the study samples were slightly basic to highly basic.
Electrical conductivity (EC) shows the concentration of dissolved salts in water and the values vary from 33. 6 mS/cm to 98. 7 mS/cm according to the USPH standards.
Total Dissolved Solids (TDS) reflect water salinity, which influences water density, osmoregulation in aquatic organisms, solubility of gases, and usability. TDS levels categorize water for various uses: For drinking, it is classified as up to 500 mg/L, for irrigation up to 2000 mg/L and for both drinking and irrigation it is classified as unsuitable as up to 3000 mg/L. The TDS content in all the collected industrial samples was found to be low. Likewise, Total Suspended Solids (TSS) and Total Solids (TS) measurements were also taken [21]'.



As Figure 1 shows, the level of river contamination rises with the growth of industries and population. The effects of industrialization and population growth on the level of pollution of the river are illustrated.
The sewage treatment plant in Jaipur is also subject to inspections from time to time. The following are the routine checkups that are conducted by the staff:

Figure 2: Staff of the Jaipur sewage treatment plant performing the routine inspection.

Wastewater can be classified as 'domestic, industrial, or stormwater' as depicted in the following figure.

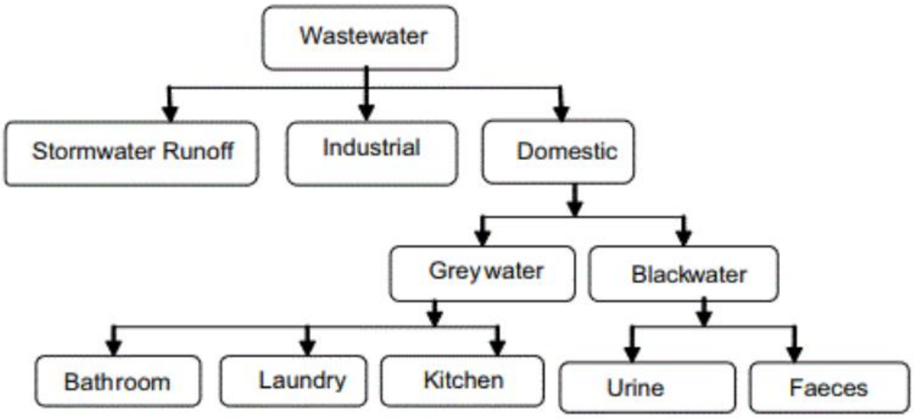


Fig. 3 Types of Wastewaters

It has been ascertained that methods of wastewater treatment that have been used in the past and new methods that are being adopted in the present are equally efficient. Comparative analysis of the two groups of methods shows that conventional methods are more automated than non-conventional techniques. These methods normally use a lot of energy in pumping and power and need professional staff in operation and maintenance [22].

REDVET - Revista electrónica de Veterinaria - ISSN 1695-7504
Vol 25, No. 1S (2024)
http://www.veterinaria.org
Article Received: 02 June 2024 Revised: 08 June 2024 Accepted: 15 June 2024

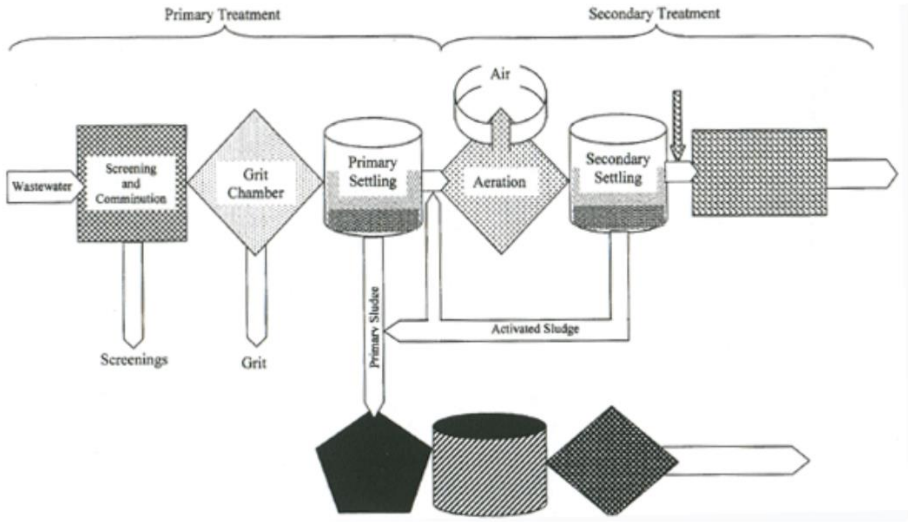


Fig. 4 Typical Wastewater Treatment Plant

Table 1 shows the operations and processes of a waste-water treatment unit.

Physical unit operations	☐ Screening ☐ Comminution ☐ Flow equalization ☐ Sedimentation ☐ Flotation ☐ Granular-medium filtration
Chemical unit operations	☐ Chemical precipitation ☐ Adsorption ☐ Disinfection ☐ DE chlorination ☐ Other chemical applications
Biological unit operations	☐ Activated sludge process ☐ Aerated lagoon ☐ Trickling filters ☐ Rotating biological contactors ☐ Pond stabilization ☐ Anaerobic digestion ☐ Biological nutrient removal

Wastewater treatment methods are categorized into three types: ‘mechanical, chemical, and biological changes’. The unit operations related to each category are shown in Table 1 below.

Table 2 shows the physicochemical parameters of Jaipur's groundwater.

CODE	pH	EC	TDS	TH	SAR	Na%
J-4	7.72	1149	611.50	175.15	6.58	71.55
J-6	7.9	791	445.00	75.06	6.73	79.60
J-10	7.4	2540	1435.14	735.56	2.63	33.10
J-12	7.73	587	296.69	225.18	1.07	26.53
J-13	9.78	345	239.46	40.04	4.47	78.17
J-14	7.84	1596	785.64	600.48	1.65	25.59
J-17	7.56	2550	982.57	845.64	0.81	12.53
J-18	8.03	1130	654.79	150.12	6.75	73.51
J-19	7.76	1704	961.63	400.31	5.89	59.69
J-21	7.56	2430	1112.60	685.52	2.19	30.23
J-24	7.93	540	275.85	150.10	1.88	43.80

Classification of water is based on the principle that was set in 1979 by the International Association of Hydrogeologists (IAH). Based on this principle, total equivalents of cation and anion are taken as 100%, and ions more than 20(me/L) are included in this classification. Table 2 gives further information on physicochemical characteristics.

Conclusion

With the increase in the population of people across the world, industries have grown to meet the needs of the people and in the process have caused many problems to the environment. Discharges and poor handling of untreated effluent are some of the major problems facing the world today with severe consequences on aquatic life affected by these pollutants. Water pollution is a global issue, though India has been experiencing the worst of this problem. Indian sages have been claiming that a man's condition influences on the quality of the food and water he takes. Hence, it is essential to manage wastewater in a proper way to avoid the spread of diseases and protect the health of the population. Wastewater treatment methods can be classified as conventional and non-conventional methods and the type of method to be used depends on the type of wastewater (municipal or industrial wastewater such as chemical, textile, pharmaceuticals, etc.), the available technical know-how, cost, and power availability.

References

1. M.Nair, (2005). Bhopal Gas Tragedy – A Social, Economic, Legal and Environmental Analysis, Pp 17. http://dx.doi.org/10.2139/ssrn.1977710. 5. R.Varma and D.R.Varma, (2005). The Bhopal Disaster of 1984, Bulletin of Science and Technological Society, Vol 25, Issue 1: Pp 37-45.https://doi.org/10.1177%2F0270467604273822.
2. D.Paul, (2017). Research on heavy metal pollution of river Ganga: A review, Annals of Agrarian Science, Vol 15, Number 2, Pp 278-286. https://doi.org/10.1016/j.aasci.2017.04.001
3. K.Biswas, D.Paul, S.N.Sinha, (2015). Prevalence of multiple antibiotic-resistant coliform bacteria in the water of river Ganga, Frontiers in Environmental Microbiology, Vol 1, Pp 44-46. doi: 10.11648/j.fem.20150103.12
4. Treatment Equipment Company "An Introduction to Membrane Bioreactor Technology" Company Information Sheet retrieved 01-10-2010
5. Sharma Surendra Kumar, Vijendra Singh and C.P. Singh Chandel (2004): groundwater pollution problem and evaluation of Physicochemical properties of Ground Water. – Environment and Ecology, 22 (spl-2): 319-324.
6. Singh Vijendra and C.P. Singh Chandel (2006): Analysis of Wastewater of Jaipur City for Agricultural Use. – Research Journal of Chemistry and Environment. 10(1): 30–33
7. Abbasi S.A., F.I. Khan, K. Sentilvelan and A.Shabudeen (2002): Modelling of Buckingham Canal Water Quality. – Indian J. Environ. Health. 44(4): 290–297
8. Grover, S.P., Bisht, S. and Bhatt, A.M. 1988. Effect of distillery wastes on physico-chemical characteristics of the Sone River in the Doon Valley. Indian J. Phy. Sci. 8:38-41
9. Chatterjee, A., Khan, I.A., Ali, M. and Mumtaz. 1981. A study on the ecology of river Kali in Aligarh. Indian J. Animal Res. 15: 63
10. Badola, S.P. and Singh, H.R. 1981. Hydrobiology of the river Alaknnanda at the Garhwal, Himalaya. Ind. J. Ecol. 8(2):269-276
11. Nair, N.B., Arunachalam, M., Madhusoodan Nair, K.C. and Suryanarayanan, H. 1989. A Spatial study of the Neyyar River in the light of the river continuum concept. Trop. Ecol. 30(1):101-110.
12. Deshmukh, S.B., Phadke, N.S. and Kothandaraman, V. 1984. Physico–chemical characteristics of Kanhan river water, Nagpur City. Environ. Hlth. 6(3): 181-183.
13. Mahdi A., Azni I., Aofah A. (2007). Combined Anaerobic-Aerobic System for Treatment of Textile Wastewater. Journal of Engineering Science and Technology Vol. 2, No. 1 (2007) 55-69 © School of Engineering, Taylor's University College
14. Fayza A., Hala S., Hisham S., Saber A. (2004) Chemical Industry Wastewater Treatment, Water Pollution Research Department, National Research Centre, Cairo, Egypt "Faculty of Engineering, Cairo University, Cairo, Egypt
15. Peavy, S. H., Rowe, D. R. and Tchobanoglous, G., (1985) Environmental Engineering, International Edition MacGraw-Hill 207-322.
16. Adu-Ahyiah, M. and Anku, R. E. "Small Scale Wastewater Treatment in Ghana (a Scenario)" Retrieved, 03-10-2010:1-6
17. National Programme on Technology Enhanced Learning (2010) "Wastewater Treatment" Course Notes www.nptel.iitm.ac.in/courses/Webcourse-contents/IIT accessed 01-09-2010
18. Water Management Forum, The Institution of Engineers (India), New Delhi, 2003, Inter-basin Transfer of Water in India – Prospects and Problems.
19. IPCC, 2001, The science of climate change, Assessment Report of IPCC Working Group I (eds. Houghton, J. T. et al. and WMP/UNEP), Cambridge University Press, Cambridge

20. E Brown, M.W Skougstad, M.J Fishman" Methods for collection and analysis of water samples for dissolved minerals and gases". Techniques for water resources investigation of U.S geological survey vol. 160 book 5 chapter A1, 1970
21. Rani Faryal, Faheem Tahir, and Abdul Hameed effect of wastewater irrigation on the soil along with its micro and macro flora pak. J. Bot. 39(1):, 2007, 193-204.
22. Bose, D. and Saxena, N., 2001, Monsoon, Employment News, XXVI, No. 8,