CHARACTERISTICS AND TREATMENT PROCESS OF WASTEWATER IN A NYLON FABRIC DYEING PLANT

M. S. Ali and S. Ahmed
Department of Chemical Engineering
Bangladesh university of Engineering and Technology
M. M. S. Khan
Bangladesh Centre for Advanced Studies, Dhaka

Abstract

This study was carried out for the establishment of a standard wastewater treatment process and its implementation in laboratory scale. Waste and treated water samples were taken from a renowned textile dyeing plant having proper water treatment facilities. Wastewater was treated in laboratory and different parameters of water samples such as metal content, acidity, solid content and biological parameters were measured using some advanced technologies. The results were presented and compared with other studies and specified standards. The values found for different parameters were within the range of standard values.

Introduction

Textiles have been an extremely important part of Bangladesh's economy for a very long time for a number of reasons. The textile industry is concerned with meeting the demand for clothing, which is a basic necessity of life. It is an industry, that is, more labor intensive than any other in Bangladesh, and plays a critical role in providing employment for people. Currently, the textile industry accounts for about half of all industrial employment in the country and contributes significantly in total national income.

The Department of textiles (DOT) is the licensing and monitoring agency for the private sector industries while the industries under Bangladesh Textile Mill Corporation (BTMC) are directly controlled by the Government. Although this sector is one of the largest in Bangladesh and still expanding, but those authorities do not concern themselves with effluent qualities and its impact on environment [1].

Effluent from the textile industry is a major source of environmental pollution especially water pollution. Among the various stages of textile industry, dyeing plant is the most pollutant producing stage. The textile dyeing wastes contain unused or partially used organic compounds, strong color and high COD and BOD. The intensity of pollution depends on the fabric, as well as dyes and chemicals used in textile industries, their fixation rate on the fabric. Beside that the dyeing sequence, dyeing equipment and the liquor ratio used in the textile industries can also affect the pollution intensity. The rate of pollution is increasing due to higher population growth and simultaneous growth of industries in the country. In Bangladesh most of the industries are built besides one or more rivers like Buriganga, Shitalakshya, Turag etc near Dhaka. But when it is not near any river then the wastewater is disposed off in nearby pond, lake or even into the land area. These liquids consisting of organics, toxic materials and some other additives when disposed into water body or land will result in the deterioration of ecology and damage of aqueous lives. This wastewater causes not only environmental problems but also thermal pollution because most of those remain quite hotter than the surrounding temperature[2]. Disposal of these wastes into watercourses or into land, with or without prior treatment was not a problem perhaps a decade ago. But in recent years number of industries are increasing and effects of the environmental pollution are also increasing very much. For the sake of our future it is now a burning question to take proper steps against environmental pollution.

This study was carried out to measure the typical effluent and treated water quality parameters along with a standard treatment in a laboratory scale. In this work YOUNGONE BANGLADESH in Savar was considered as a typical nylon dyeing plant and water from there was used as samples. Dyeing process used in that plant is discussed elsewhere[3].

Experimental

The experimental work can be classified into four steps [4]

- Qualitative analysis of the raw waste water
- Treatment of the waste water in the laboratory
- Qualitative analysis of the laboratory treated water
- Qualitative analysis of the water treated in the industry

All the elemental tests of the waste water as well as the laboratory treated water and the water treated in the industry were done simultaneously combining manual and automatic procedures. The procedure of wastewater treatment is discussed in details and block diagram of treatment process is shown in Fig. 1.

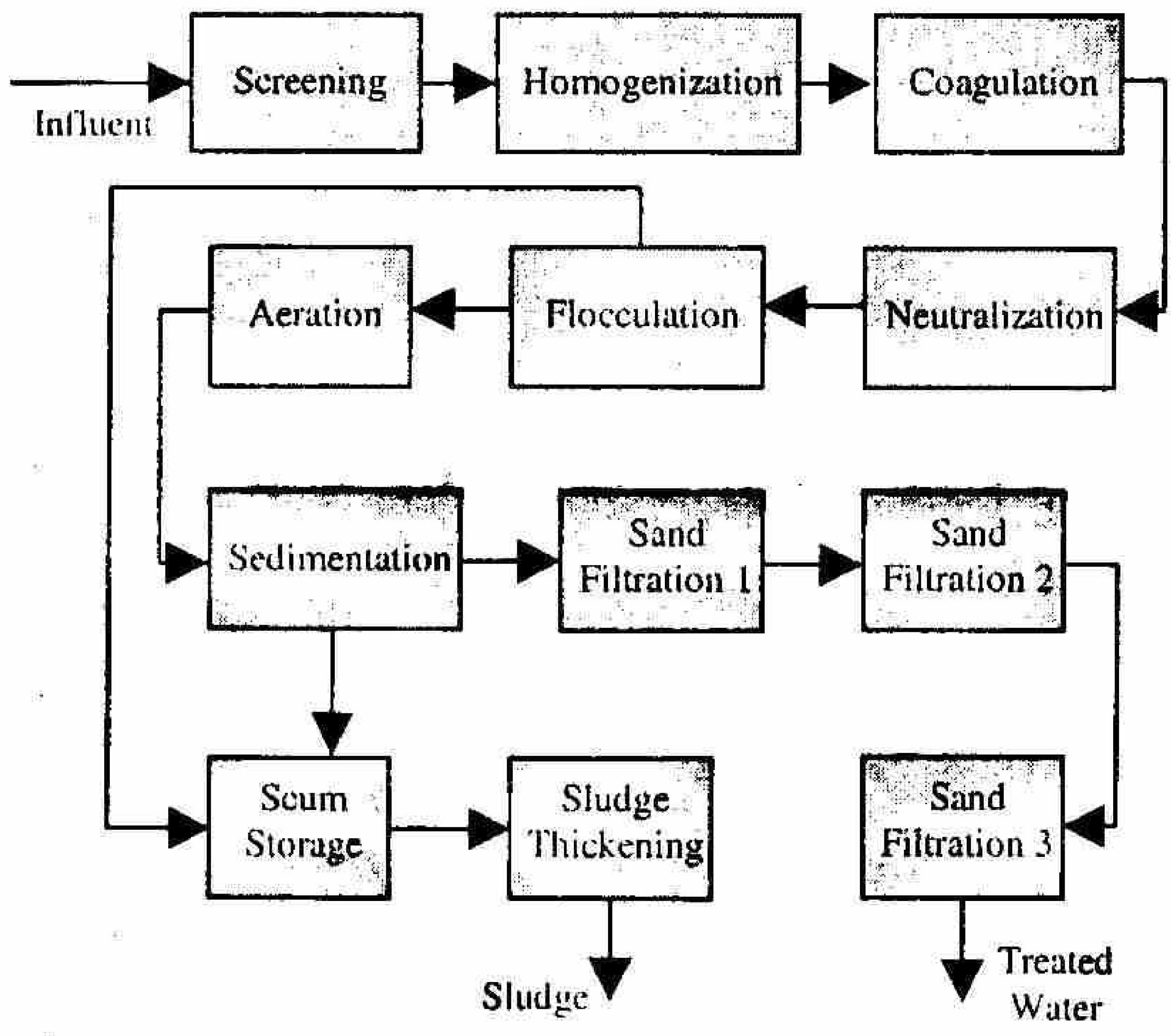

Fig. 1: Block diagram of wastewater treatment process

A *HACH DR-4000* spectrophotometer shown in Fig. 2 was used to measure elemental properties. Along with that a *Denver Instrument (Model-215)*, which is a portable microprocessor-based, pH, conductivity, TDS, DO measuring device, was especially used in the laboratory.

The process for textile wastewater treatment was done in laboratory scale[5, 6]. For that whole treatment process 300 ml sample was taken. Homogenization, coagulation, flocculation, pH control, floatation, aeration, sedimentation and filtration were included in this process. At first the sample was taken in a beaker and homogenized by a magnetic stirrer for 5 minutes. After homogenization process, Total Dissolved Solid (TDS) of the sample was measured by an automatic HACH reader.

The magnetic stirrer was started again and the sample was prepared for coagulation process. 0.188 gm (optimum amount selected from several trials) of Aluminum Sulfate (Alum) was added in the sample as a coagulating agent. Sample was stirred for 5 minutes for proper mixing of alum with sample wastewater. During the process separation of solid waste was observed.

After coagulation process, TDS and pH were measured again. Observing the pH, the requirement of neutralization unit was determined as in alkaline medium solid separation and precipitation is better than in acidic medium. High performance of microbial activities in biological treatment was ensured at pH in between 7 to 8, so the water was maintained neutral. The pH was maintained to at least 7 by adding 1 drop of 50% (w/w) Sodium Hydroxide (NaOH) in that acidic solution. At pH control unit, Total Suspended Solid (TSS) was measured by evaporation method and sample was transferred into flocculation unit.

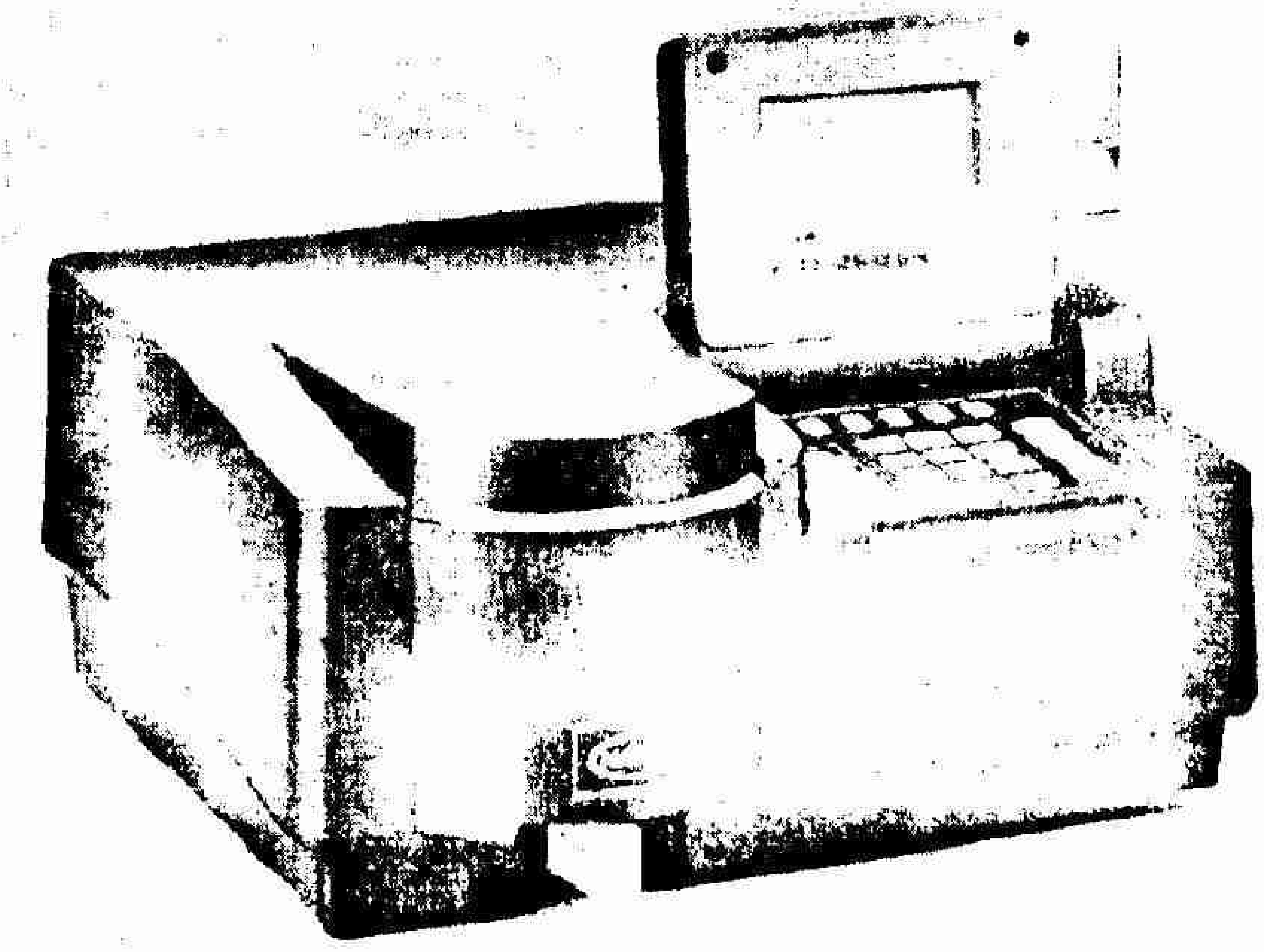

Fig. 2: HACH DR 4000 Spectrophotometer

In a separate container the flocculating solution was prepared by using 0.076 gm of a commercial flocculating agent (known as *Best Flock*) and 150 ml distilled water. In flocculation unit 3 ml of prepared flocculating solution was added and the magnetic stirrer was used for 1 minute for proper mixing. Then the stirrer was stopped and sample was kept for 5 minutes for flock formation. After flock formation, an appreciable amount of flock was removed and the TSS of the sample was measured.

The sample was then taken in the aeration unit containing some aerobic microorganisms collected from an existing biological treatment plant, where air was supplied through a coil of PVC pipe connected with a blower. Using cow dung as a source of microorganisms is common practice in Bangladesh. But generally cow dung possesses anaerobic microorganisms, which are not effective for textile effluent treatment. For successful biological treatment specific type of bacteria (e.g., *E. coli*), protozoa (e.g., *Entamoeba histolytica)*, helminthes (e.g., *Trichhuris trichiura* eggs) and viruses are to be used[7]. These microorganisms consume the organic compounds present in textile effluent as food and thus decrease the dissolved solid and produce suspended solid, as well as reduce the oxygen demand of the effluent water. As additional nutrient, Urea fertilizer and a commercial nutrient (known as *Than-bion*) were used. This process was continued for 8 hours. Thus the water was biologically treated and then sedimentation was done in that chamber for half an hour.

For sand filtration, a sand filter was used having four layers of different sieve size sands. The most bottom layer consisted of 40 mesh number of local sand. The sample was then passed through the sand filter three times that acted as three sand filters in series. After sand filtration the effluent was completely treated and taken for quality testing.

Results and discussion

Different observed and calculated data have been taken for different parameters during the laboratory work. The wastewater treatment laboratory work was mainly of two types: qualitative analysis and treatment in laboratory. The qualitative analysis of three samples is added in Table-2 for better comparison between those samples. Some of the parameters have been compared graphically along with their tabular representations.

Homogenization

During homogenization, mixing is usually provided to ensure adequate equalization, uniform pH and to prevent settleable solids from depositing in the basin. In addition, the oxidation of reduced compounds present in the waste-stream or the reduction of COD by air stripping may be achieved through mixing and aeration. Different water quality parameters after homogenization are shown in Table-1.

Table-1: Property of water after homogenization

TDS (mg/l)	TSS (mg/l)	TS (mg/l)	pH
1319	811.5	2130.5	7.83

These figures represent the initial average condition of effluent before introducing any chemical or biological treatment, which is far above both the Environmental Protection Agency (EPA) and Bangladesh (BD) national standard [8].

Coagulation and Flocculation

Coagulation is the method by which chemicals are dispersed to change the characteristics of the suspended particles so that agglomeration will occur. In coagulation zeta potential is reduced by ions or colloids of opposite charge to a level below the Van der Waals attractive forces, and the micelles aggregate and form clumps that agglomerate the colloidal particles[9]. Flocculation is the process of bringing together fine particles so that they agglomerate. The mechanism of flocculation by polyelectrolyte, whose charge is of the opposite sign to the charge on the particles, is considered to involve the processes of surface charge neutralization and bridging. The charge density of the polymer will be an important measure of its capacity to flocculate[10]. The process of charge neutralization and bridging then proceeds as shown in Fig. 3. After these steps TS dropped from 2130.5 mg/l to 1533.33 mg/l. It further dropped after sand filtration, whereas, maximum limit as per Bangladesh standard is 2200 mg/l. So, this figure was quite acceptable according to BD standard. The change in total solids due to coagulation and flocculation is graphically represented in Fig. 4.

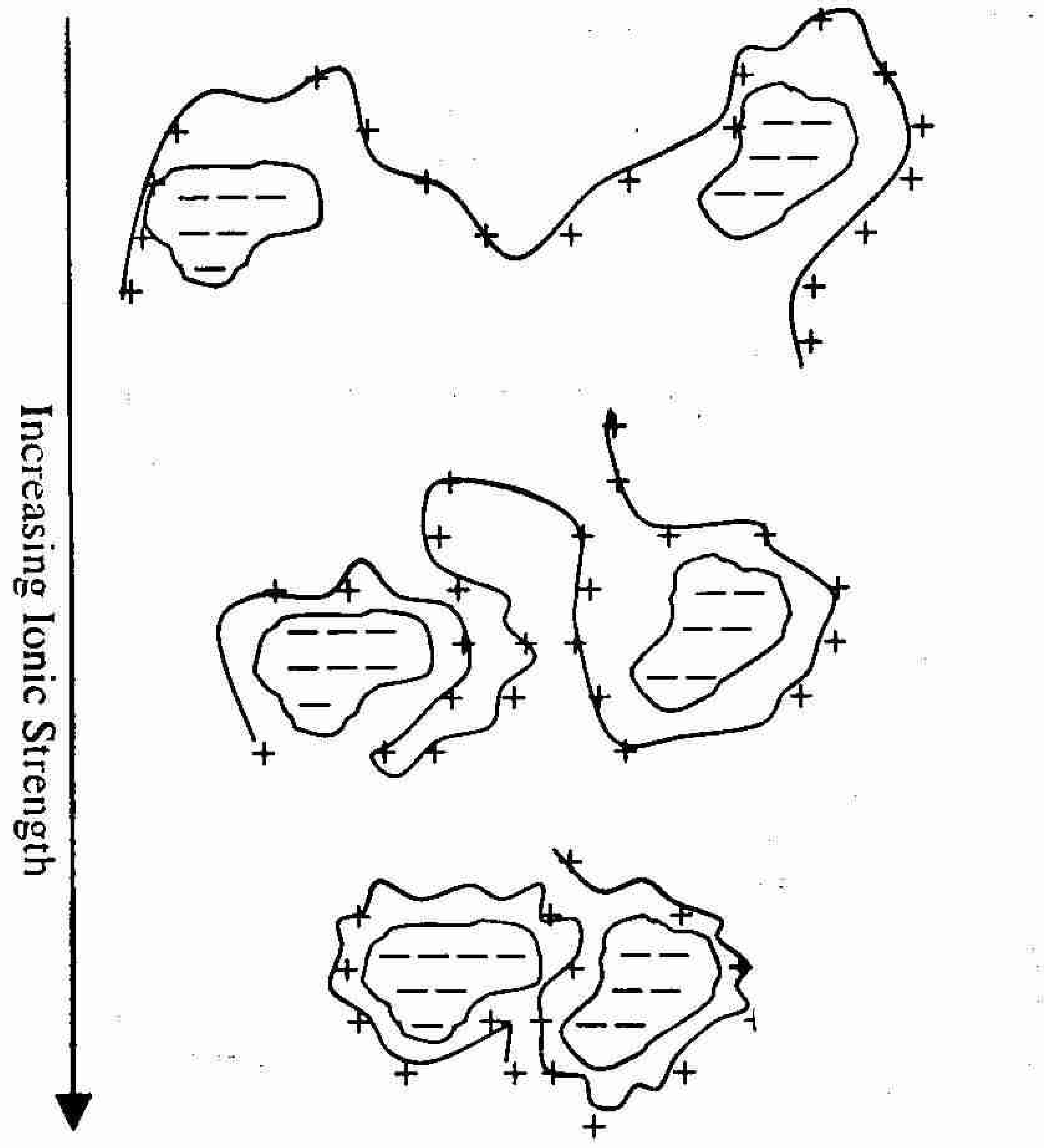

Fig. 3: Flocculation by charge neutralization and bridging

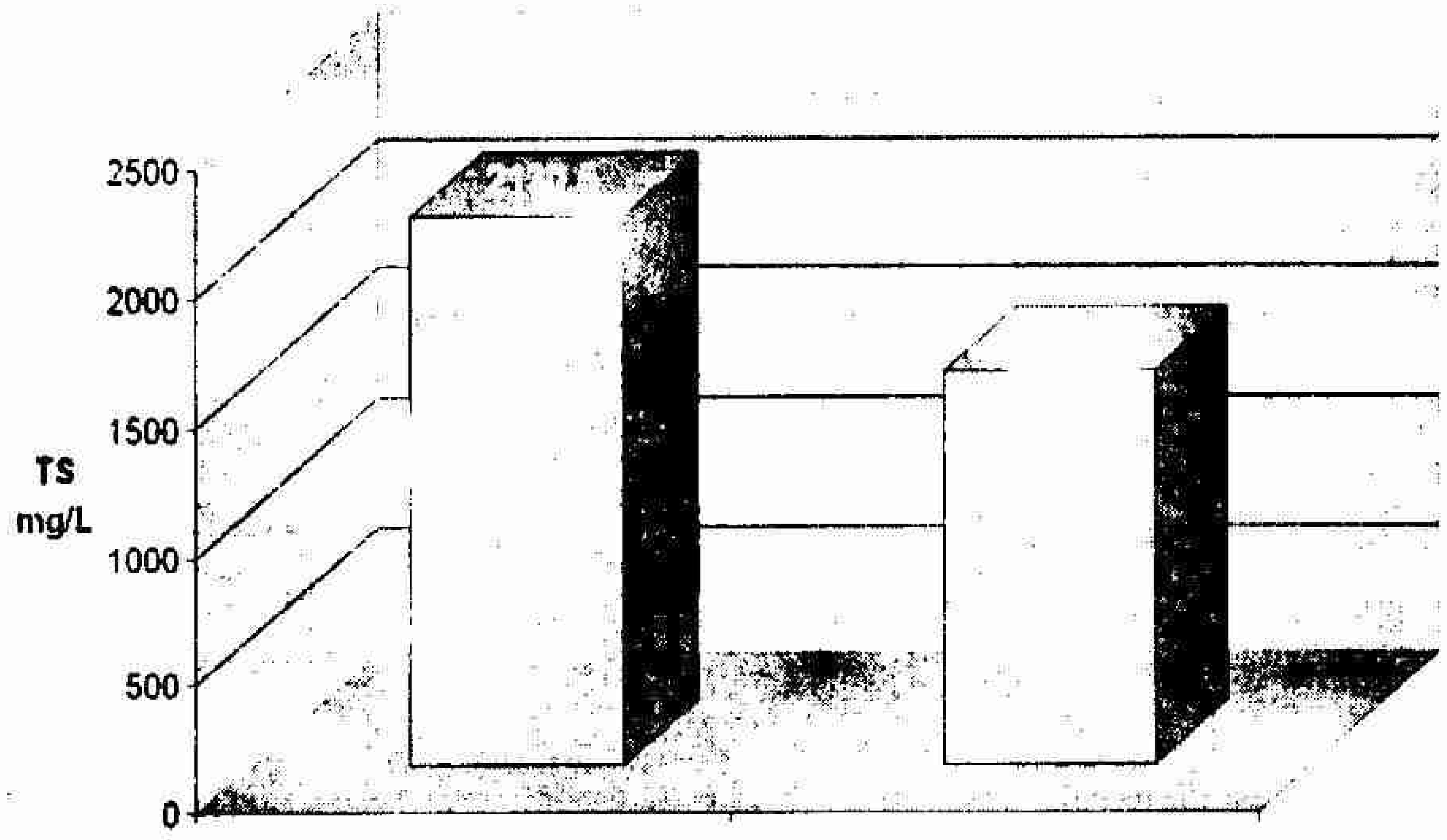

Fig. 4: Change in TS after Coagulation and Flocculation

Neutralization

After coagulation the process water was little bit acidic so pH of the water was changed to alkaline. Before any treatment, water pH was 7.83. After addition of the coagulant it turned acidic with a pH 5.81. This step of neutralization was used to regain its apparently neutral characteristics and the pH was brought to 7.70.

According to EPA and BD standards it should be 6.0–9.0 and 6.5– 9.0 respectively. So this value of pH was within the range of those standards. The results are shown in Fig. 5.

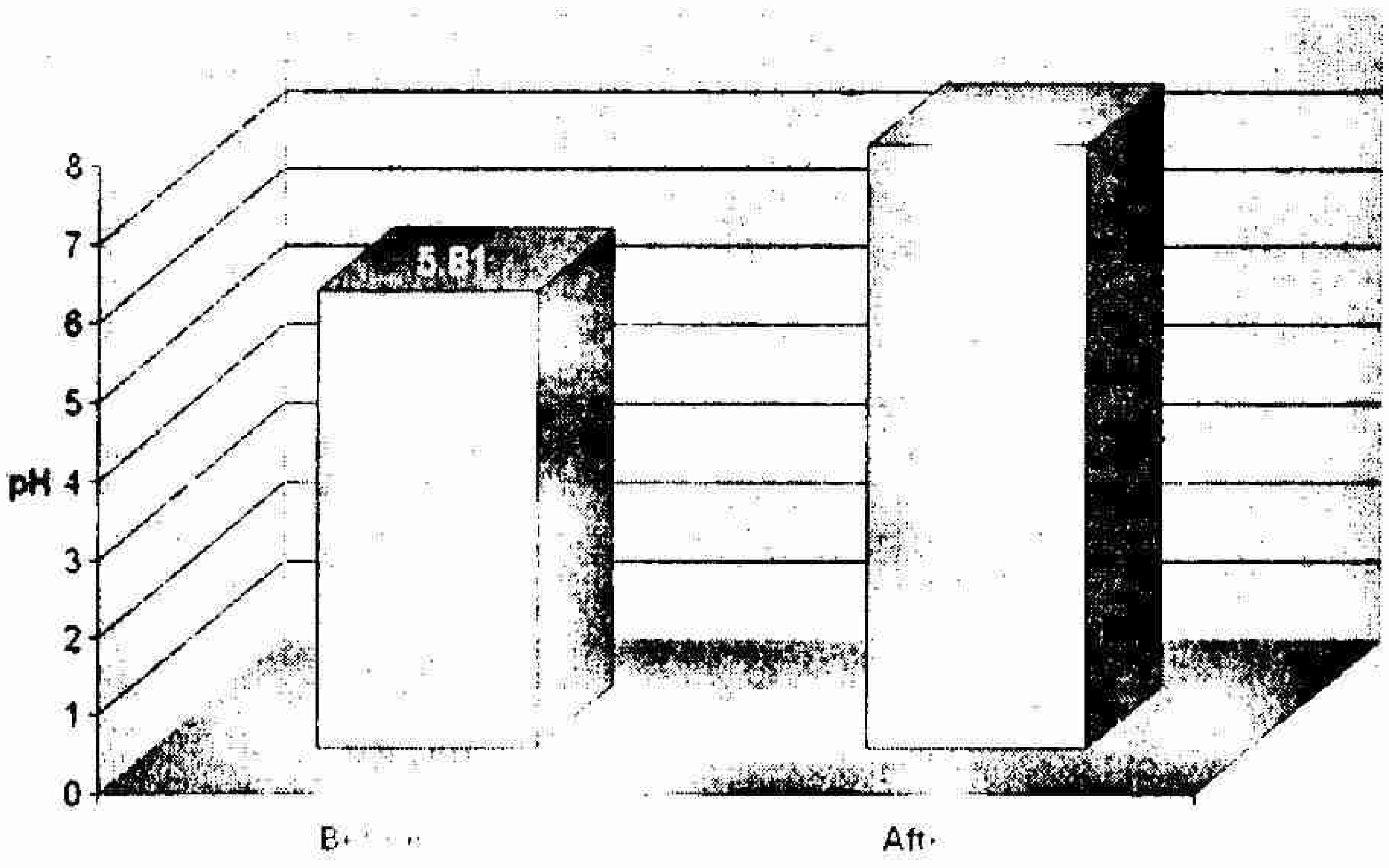

Fig. 5: Change in pH due to Neutralization

Aerobic Biological Treatment

In the biological treatment process variables such as BOD and COD were changed. Due to the increase in nutrients the number of microorganisms increased rapidly. But after a certain period the number decreased with diminishing amount of nutrient. The BOD and COD decreased respectively [9]. The values of BOD and COD after the aeration step were found 11.4 mg/l and 30 mg/l respectively whereas the EPA standard limit for that are maximum 30 mg/l and 200 mg/l respectively. According to BD standard it should be within 150 mg/l and 400 mg/l respectively. Considering both the standards, the values of BOD and COD after the treatment are well acceptable.

Sand Filtration

In this process the treated water from aerated biological treatment was passed through a sand filter. The whole filtration was performed three times, which acted as three sand filters in series. Total Suspended Solid content was reduced from 264.33 mg/l to 37 mg/l by using sand filtration. This value is quite close to Environmental Protection Agency (EPA) standard, 30 mg/l.

Comparison of Different Parameters among the Samples

Total solids (TS) of the wastewater were changed in several stages. Before any treatment the TS was 2130.5 mg/l and after coagulation and flocculation it turned to 1533.33 mg/l. Some suspended particles were removed also by sedimentation and filtration so TS decreased further to 1318 mg/l. Changes in total dissolved solids and total solid values throughout the treatment process are graphically shown in Fig. 6 and Fig. 7 respectively.

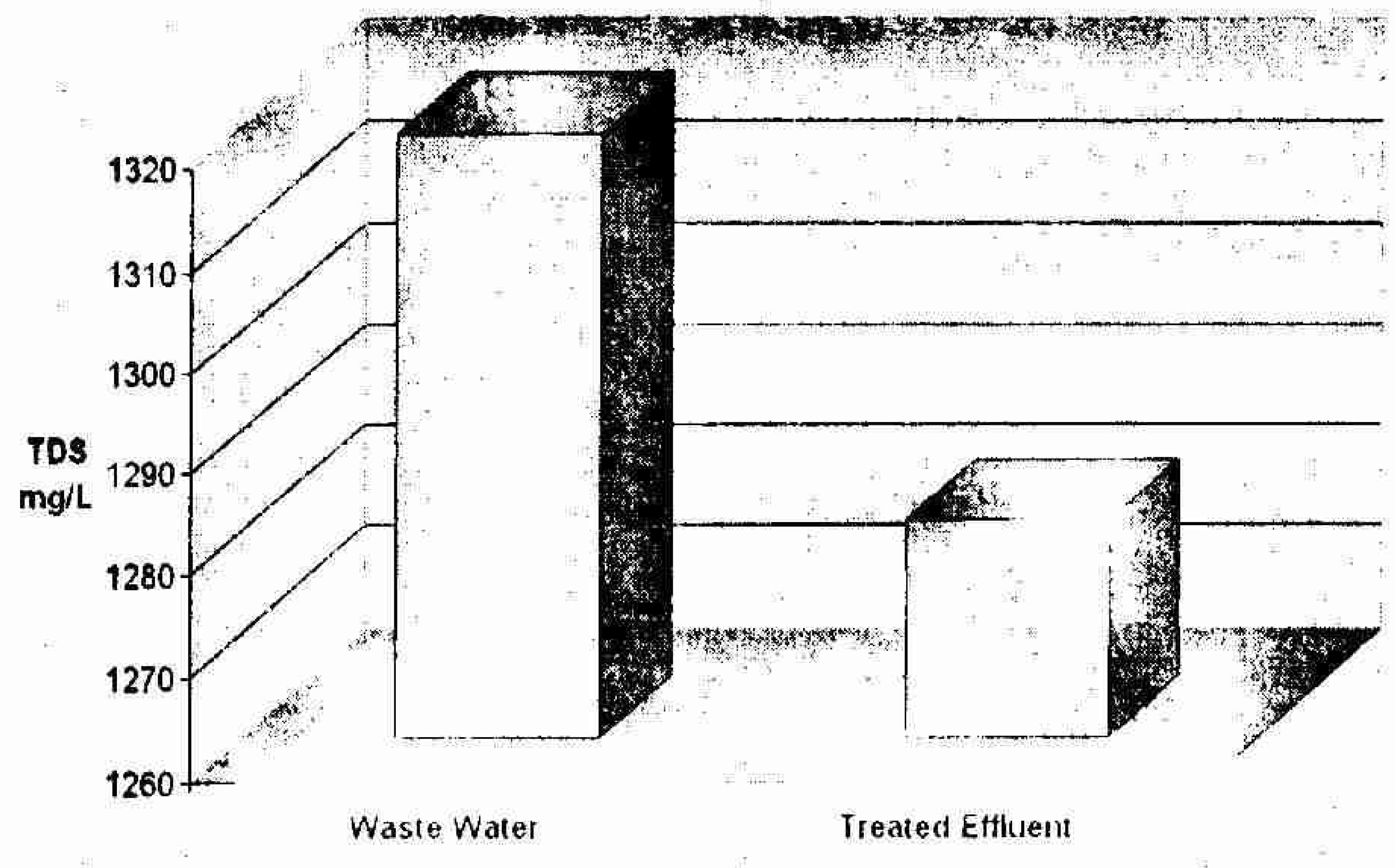

Fig. 6: Change in TDS during the treatment Process

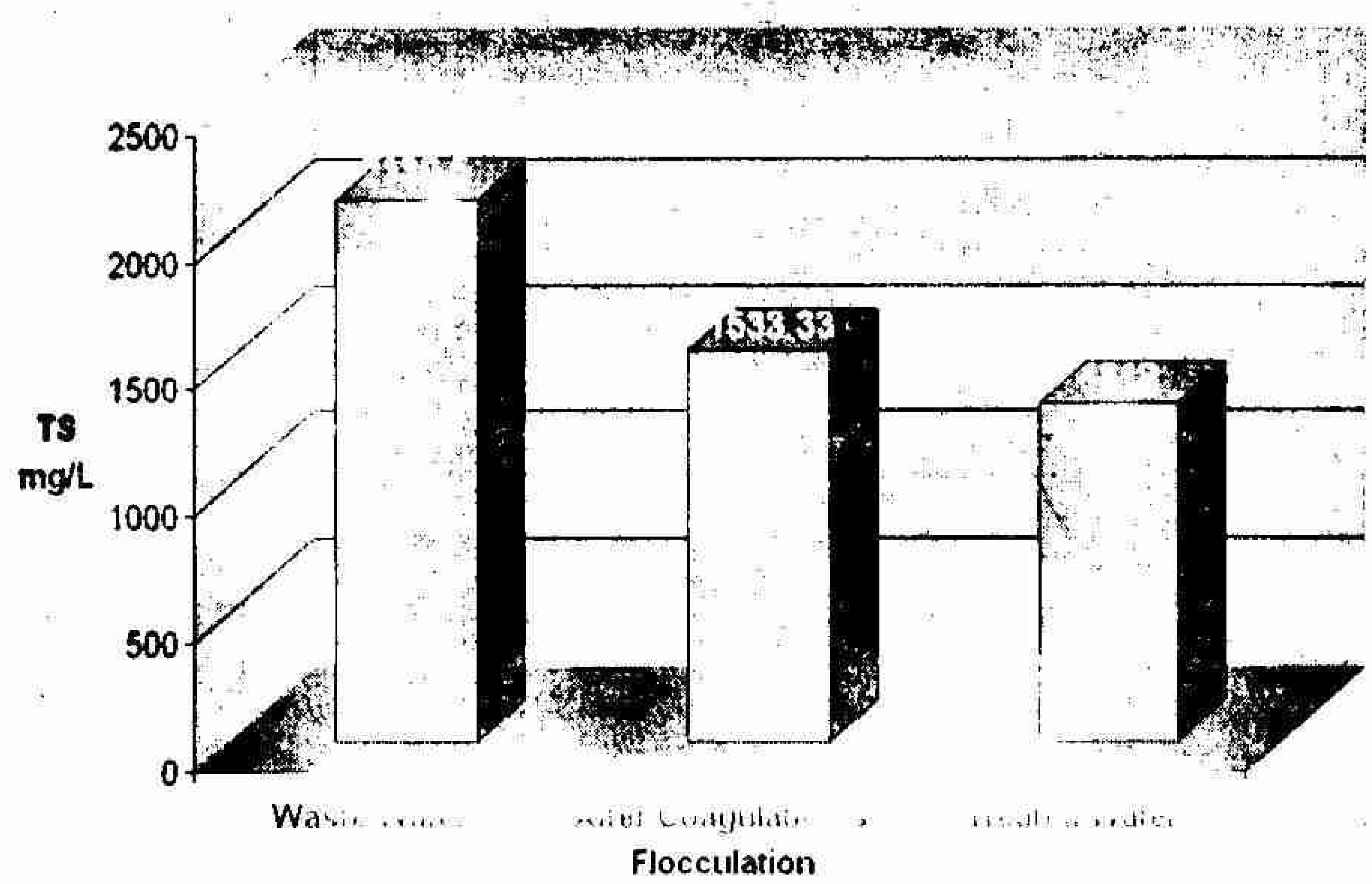

Fig. 7: Change in TS during the treatment Process

All the parameters like metal content, turbidity, hardness and others were found within the acceptable range according to the EPA standards. The biochemical oxygen demand (BOD) was measured on a 5-day basis and considered as BOD_5. Comparisons of BOD and COD among the three samples are shown in Fig. 8 and Fig. 9 respectively. Wastewater was rich in biological organisms and so BOD_5 was too high as 481 mg/l. The water treated in the laboratory was found in better condition than the industrially treated water. The BOD_5 of laboratory treated water was 11.4 mg/l and that of the industry was 14.9 mg/l. Chemical oxygen demand (COD) of the laboratory treated water was also less than the industrially treated water. Initially COD value was as high as 927 mg/l and decreased to 30 mg/l, whereas the COD of industrially treated water was 61 mg/l. So laboratory results obtained for BOD and COD are lower than the industrial treated water and within the acceptable range according to both EPA and BD standard as mentioned in previous section.

Elemental properties of three different samples are summarized in Table-2. In some cases the laboratory treated water quality was found better than the industrial treated water. Treatment method done in laboratory was acceptable because the metal concentrations, BOD, COD, solid content were reduced to a large extent and all of the parameters were within the range of both EPA and BD standards. This was due to establishment of an effective sequence of treatment process but mostly because of some extra filtration stages added in that sequence. Besides, the major problem was in the solid waste developed during the treatment. The solid waste was separated to dump underground but that is not a permanent solution.

Table-2: Elemental Properties of three different waters

Parameters	Raw Water	Laboratory Treated Water	Industrial Treated Water	Unit
DO	7.0	13.2	17.4	mg/l
BOD	481	11.4	14.9	mg/l
COD	927	30	61	mg/l
TS	2130.5	1318	1585	mg/l
TDS	1319	1281	1556	mg/l
TSS	811.5	37	29	mg/l
Turbidity	212	26	38	FAU
pH	7.83	7.88	7.82	
	3.82	0.72	1.09	mg/l as $CaCO_3$
Total hardness	1.528	0.288	0.436	mg/l as *Ca*
	0.933	0.176	0.266	mg/l as *Mg*
Chromium (Cr)	0.205	0.015	0.02	mg/l
Calcium (Ca)	2.42	0.49	0.84	mg/l as $CaCO_3$
	0.968	0.196	0.336	mg/l as *Ca*
Magnesium (Mg)	1.40	0.23	0.25	mg/l as $CaCO_3$
	0.342	0.056	0.061	mg/l as *Mg*
Copper (Cu)	0.21	0.138	0.05	mg/l
Nickel (Ni)	0.37	0.025	0.27	mg/l as Ni^{+2}
Cadmium (Cd)	1.50	0.03	0.01	mg/l
Lead (Pb)	3.70	Trace	0.005	mg/l
Iron (Fe)	0.55	0.755	0.60	mg/l
Barium (Ba)	163.4	3.60	Trace	mg/l

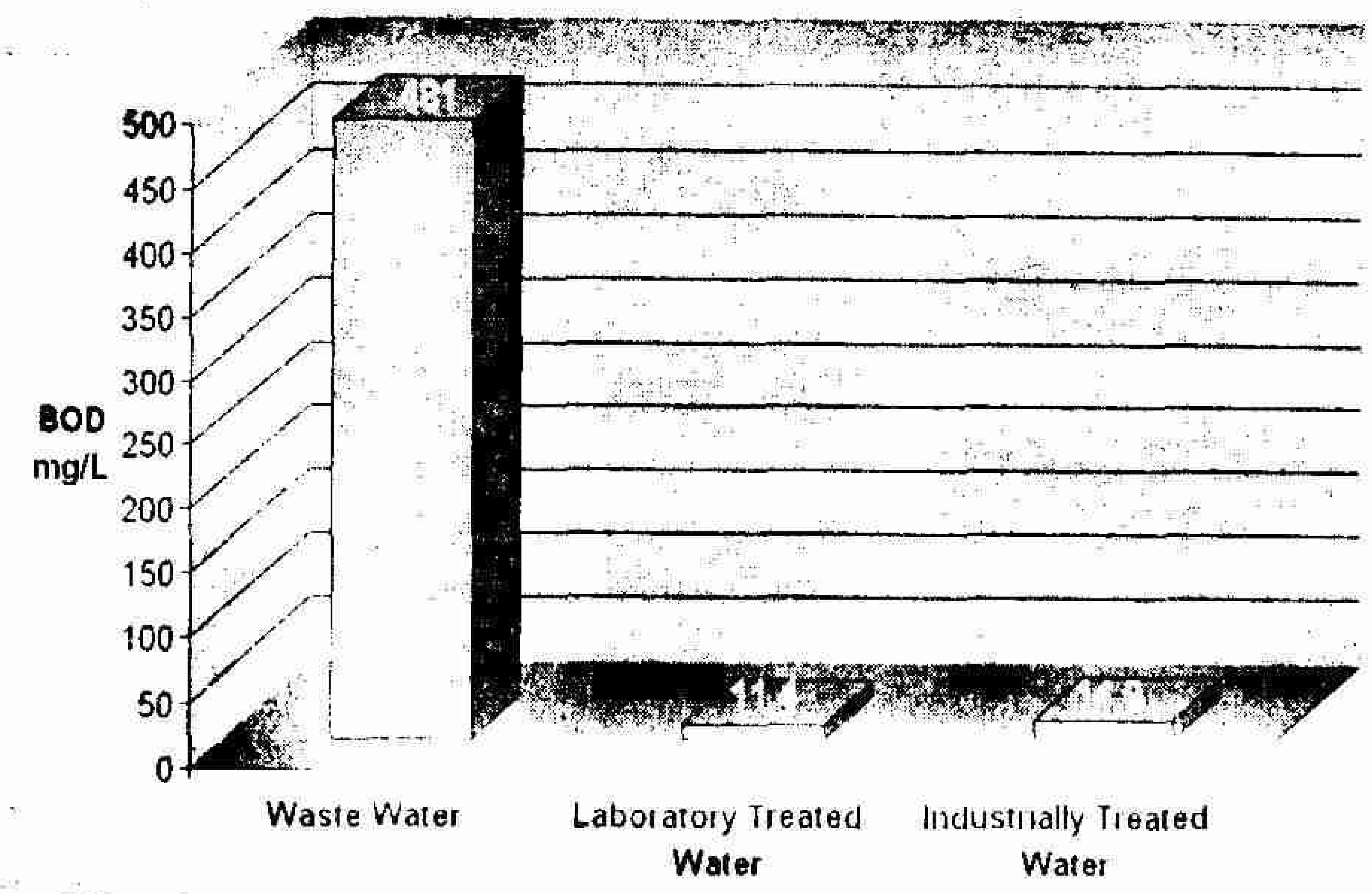

Fig. 8: Comparison of BOD among three samples

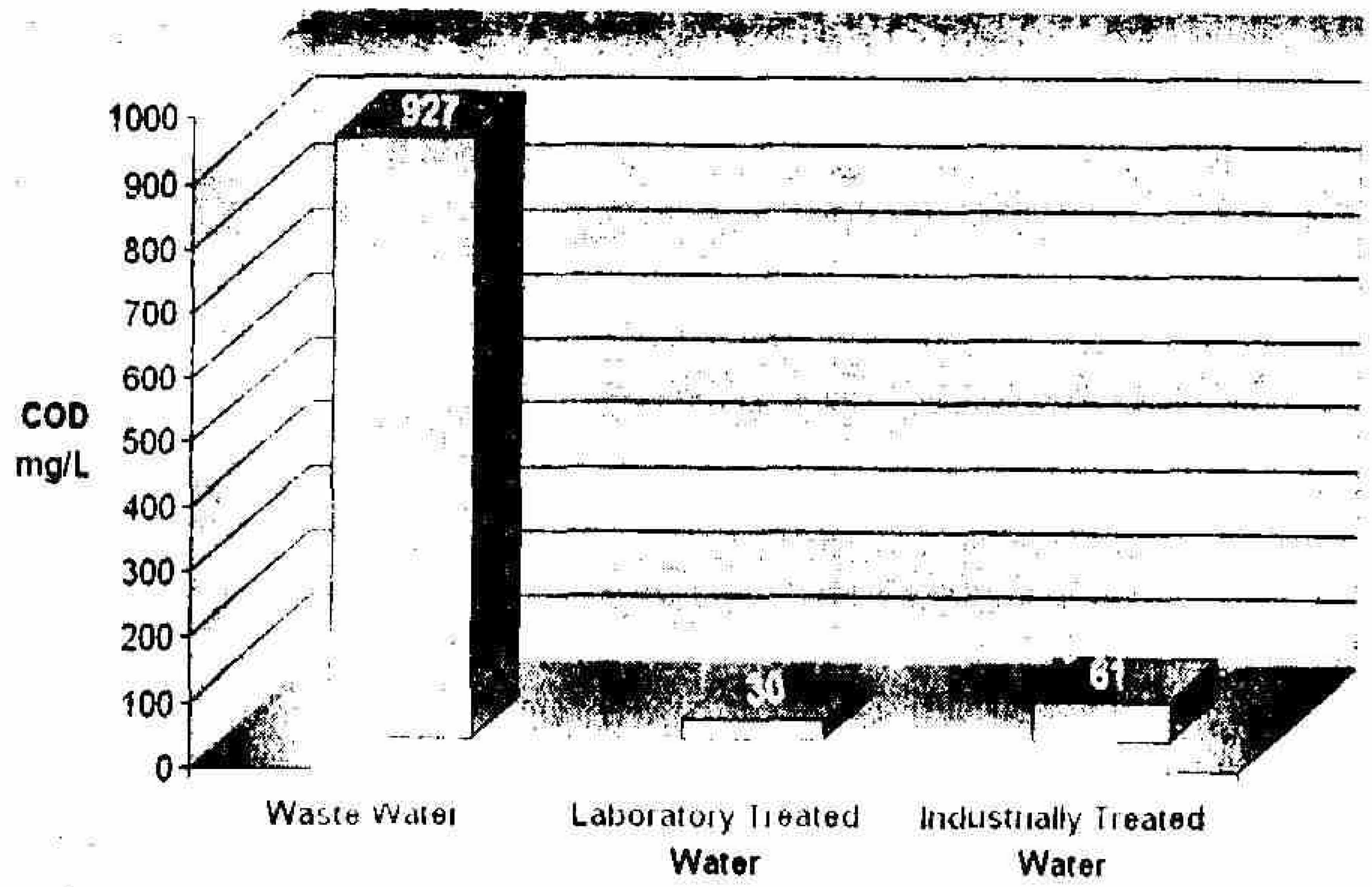

Fig. 9: Comparison of COD among three samples

Since this study was carried out to treat the wastewater completely so a successful treatment sequence has been established to fulfill the objective.

Conclusion

Developing countries throughout the world are facing ever more stringent pollution restrictions. Because of economic constraints and the need to develop an industrial base, many developing countries have ignored pollution control within their industries. As a result several regions of the world are being environmentally polluted, with the subsequent degradation of their quality of life. These problems are ubiquitous throughout the developing world, and have led these countries to search for "appropriate technologies" for pollution control.

Among the different sources of water pollution, pollution by textile industry is a major one and now increasing in Bangladesh. There are environmental rules and regulations for the textile dyeing industries, but these are not implemented in the dyeing industries. To meet the wastewater management objectives, some major factors have to be considered. These include source and characterization of wastewater, determination of treatment process, control of effluent and last but not the least sludge and solid waste management. To make the wastewater treatment more meaningful, segregation of process water and reuse of treated water can be introduced in the textile industries. Moreover solid waste can be processed by means of land filling, land farming, incineration and solidification. For a country like Bangladesh land-farming and solidification processes could be very useful. Unfortunately these things are not practiced widely in Bangladesh. Among the few wastewater treatment plants in Bangladesh, most of them are bought as a package without any indigenous contribution. But from the successful implementation of the treatment process in laboratory, it is clear that wastewater treatment plant can be established and operated successfully using conventional technologies and local manpower. These should be considered and practiced more widely for the sake of our future generations.

Acknowledgement

We are grateful to the authority of YOUNGONE BANGLADESH for visiting their effluent treatment plant and allowing to work in wastewater treatment process.

Reference

1. Rahman, M. M., Kamruzzaman, M. and Islam, M. S., Treatment of liquid effluents from textile dyeing plants, Paper no. ChE 03-18, Annual paper meet, Jan 23, 2003; ChE division, Institute of Engineers, Bangladesh.
2. Ilias, Shamsuddin, Ph.D., P.E., Water Pollution Management, Solid and Hazardous Waste Management, Environmental Management Considerations, paper presented in Workshop on Environmental Protection and Pollution Prevention Issues and Initiatives (2002).
3. Islam, M. S., Ali, M. S., Rahman, M., Hossain, A. and Mohiuddin, M., Study on Shrinkage Loss in Dyeing and Finishing of Nylon Fabrics at Savar Dyeing and Finishing Industries Ltd., Paper no. 051, International Conference on Chemical Engineering, 2003, BUET, Dhaka.
4. Ahmed, Shoeb and Khan, Md. Mohidus Samad, Study of Wastewater Treatment Process of a Synthetic Fabric Dyeing Plant, B.Sc. Engg. Thesis, Chemical Engineering Department, BUET (2004).
5. Lash, D. Leslie, and Kominek, Edward G., Primary-Waste-Treatment Methods, paper published in Chemical Engineering Magazine, Industrial Wastewater and Solid Engineering (1980).
6. Mulligan, J. Thomas, and Fox, D. Robert, Treatment of Industrial Wastewaters, paper published in Chemical Engineering Magazine, Industrial Wastewater and Solid Engineering (1980).
7. Metcalf & Eddy, Waste Water Engineering Treatment Disposal Reuse, 4th edition, McGraw-Hill, New York (2003).
8. Guide to the Environmental Conservation act 1995 and rules 1997, 1st edition, Bangladesh Centre for Advanced Studies.
9. Eckenfelder, Jr., M. Wesley, Industrial Water Pollution Control, 2nd edition (1989).
10. Hughes, M. A, Coagulation and Flocculation, published in Solid liquid separation edited by Svarovsky, L, 3rd edition, Butterworth-Heinemann Ltd (1990).
