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Management of Industrial Effluent from Paper and Pulp Industries Using Gravimetric Circular Clarifier Technique

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Abstract. The present study was carried out to determine the standardization of a suitable method for treatment of industrial effluents from paper and pulp industries in Pakistan. Effluent samples were collected from two paper industries in Punjab and analyzed for the following parameters: BOD, COD, sulphates, chlorides, TH, TS, TSS, TDS and pH. The results obtained were compared with National Environmental Quality Standards and World Health Organization limits. On the basis of comparison, innovative methods of water treatment were recommended. A circular clarifier was found to be the most effective and cheapest technique based on effluent analysis. In addition, gravity sedimentation and coagulation processes were used as these processes not only reduce BOD, COD and other pollutants to meet the Industrial and National Environmental Quality standards and limits.

Keywords: effluent, paper, BOD, COD, clarifier, coagulation

1. Introduction

Water pollution is a serious threat to the society and presents a challenge which must be met to achieve the goal of proper supply, demand and development. The problem of water pollution has increased over the years mainly due to rapid industrialization, urbanization and population growth [1]. Polluted water bodies are considered to be unfit for public water supply, industry and recreational purposes. It is a major contributory factor to a number of water born diseases [2]. Industrialization has an unavoidable effect on pollution of air, water and soil based on the type of industry, nature of raw materials used and manufacturing processes involved [3]. It is the index of modernization but unfortunately leads to fluctuation in physical, chemical and biological properties of the environment [4]. Since both industrialization and pollution are complementary to each other, different measures need to be adopted so that pollution can be rendered less harmful to the biosphere. There is wide spread reluctance on the part of all industries in developing countries to treat their wastes as the treatment plants require substantial and colossal financial investment. In Pakistan, various industries were constructed which resulted in unforeseen discharge of untreated effluents into receiving bodies of water or in natural streams which are being utilized by down-stream consumers, both human as well as animal [5]. The paper and pulp industry is the tenth largest industry of Pakistan with per capital paper consumption of 3.5 kg/year [6]. It is considered to be one of the most prominent industries contributing to discharge of manmade pollutants and consequently potential problems due to water pollution are a serious concern [7]. The production of paper products in Pakistan is mainly due to grass and local wheat straw. Other raw materials used are bagasse, rice straw and cotton linter [8]. The present installed capacity of paper & board mills is nearly 900,000 tons. The paper and pulp industry comprises of 100 paper mills and paperboard production. The utilization capacity is 434,740 tons (2011) with more than 70 % of mills located in Punjab, Sindh (20%) and the rest in Khyber Pakhtunkhwa (10%) [9].

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While many of the paper units are located in the urban vicinity of the country, wastewater treatment is necessary to reduce pollution in water streams in order to provide better hygienic conditions. Acids and alkalis discharged by industrial plants not only make a stream unsuitable for recreational purposes but aquatic life is also affected. Certain organic chemicals, such as phenol, are known to pollute domestic water supplies which may cause superfluous medical problems [10]. The Organization of International Standards, ISO 14000, is compelling the industrial community to install water treatment plants in Pakistan with the paper industry being imposed stringently. The current work focuses on identification of the potential sources of effluent being discharged from the paper industry, optimization of the doses of various chemicals by treating effluent on laboratory scale and to determine the effectiveness of effluent treatment techniques for recommendation of possible solutions to manage and control paper and pulp effluent.

2. Materials and Methods

Effluent samples, between 3-5 litres, were collected in clean sample bottles from two paper mills in Punjab, Pakistan. The sample bottles were labeled viz: origin of sampling, sampling point, sampling procedure (time or flow proportional or not, grab sample), date and time of sample start to finish, wastewater flow during sampling period (m^3/hr). At the final discharge point, the samples were collected automatically proportional to flow. For other check points a grab-sampling method was employed to obtain a composite sample. Care was taken to avoid a build-up of dense suspended particles. In pipes, containing pulp, the sampling pipe was extended into a transport pipe a distance equal to 30 percent of the larger pipe diameter in order to avoid wall effluents. Samples from channels were taken at some distance from the bottom in order to prevent sediment particles from entering the sample in representative quantities. In the case of grab sampling, at least 6-12 grab samples were taken during a 24 hour period to ensure a composite sample. The composite shift samples were collected at block check points whenever a large variation in discharge occurred. Effluents samples for toxicity, BOD and COD tests were stored in a dark, cool place (4 ℃) immediately after sampling. Daily composite samples required refrigeration during the sampling periods in order to minimize bacterial growth. Temperature and pH of the samples was recorded immediately after sampling. All chemicals used were of analytical grade (Merck, UK).

2.1. Gravimetric Circular Clarifier Method

Effluent from all the processes was fed to rotary screen to remove litter and huge particles after which it enters a mixing tank where coagulation is applied for removal of colloidal particles by the addition of alum (5mg/L). Small particles of color, turbidity and bacteria are converted into larger flocs as suspended particles. Coagulants used were aluminum and ferric. An air diffuser agitator was used for mixing to inhibit bacterial growth. After this flocculation was carried out in a flocculation tank to obtain smaller particles in contact, so that they collide, stick together and reach a size to become a solution mix in order to make a Floc Floc and keep it from settling in the flocculation tank. The flocculant used was ferric chloride and white water to improve the phenomenon. The flocculant was then fed to a clarifier and then to a sludge tank where sludge was removed and effluent treated was drained in channel.

3. Results and Discussion

The objectives of the study were to optimize the values of effluent parameters to meet NEQS and to determine the effectiveness of effluent treatment techniques. Experiments were performed on two samples of paper and pulp industries and results of various parameters were obtained. The results show that all of the effluent parameters meet NEQS except total hardness. Table 1 shows analysis of untreated effluents by paper and pulp industries. The parameters studied prior to water treatment methods do not meet the NEQS and W.H.O limits (Table 2). The effluents drained by paper and pulp mills have a high concentration of pollutants such as BOD, COD, TDS, TSS, chlorides, sulphates and hardness. These high values of effluent parameters are harmful for human and marine life. The objective is to achieve effluent ecologically acceptable levels. Innovative methods of treatment were studied and Gravimetric Circular Clarifier Technique was found to be a cheap and effective method. By applying this technique, the results obtained are shown in Table 3. A comparison of treated and untreated effluents is shown in Table 4. As evident from the data, the results show that there is almost a 25% reduction in BOD, COD, TSS, chlorides and sulphates while

20% decrease in TDS. After application of the Gravimetric Circular Clarifier Technique method of treatment it was found that all the effluent parameters met the NEQS and hence, the effluent was not harmful for human and marine life.

Table 1:- Parameters studied for untreated effluent samples A and B

Parameter	**Sample A**	**Sample B**	**NEQs**
Colour	Deep pink	Yellow	Unobjectionable
Odour	Unpleasant	Unpleasant	Unobjectionable
Temperature	35°C	32°C	40°C
pH	9.0	6.5	6-10
TSS	157 g	165 g	150 mg/l
TDS	4,270	2,560	3500 mg/l
TH	390 ppm	377 ppm	-
Cl^- present	1,366.8 mg/L	1,485.8 mg/L	1000 mg/l
SO_4^{2-} present	688 mg/L	656 mg/L	600 mg/l
BOD_5	88 mg/L	96 mg/L	80 mg/l
COD	224 mg/L	256 mg/L	150 mg/l

Table 2:- WHO limits for effluent parameters

Parameters	**Desirable levels**	**Permissible Levels**
pH	7.0 – 8.5	6.5 – 9.2
Odor	Unobjectionable	Unobjectionable
Color	5 units	5 units
Taste	Unobjectionable	Unobjectionable
TDS	500	1500
Calcium	75	200
Magnesium	50	150
TH	100	500
Sulphate	200	400
Chloride	200	600
Iron	0.1	1.0

Table 3:- Analysis of Treated Effluents by Applying Clarifier Techniques

Parameter	**Sample A**	**Sample B**	**NEQS**
TSS	135 mg/L	146mg/L	150 mg/L
TDS	3450 mg/L	3210 mg/L	3500 mg/L
TH	390 ppm	377 ppm	-
Chlorides	886.2mg/L	920.5 mg/L	1000 mg/L
Sulphates	505 mg/L	480 mg/L	600 mg/L
BOD_5	66 mg/L	72 mg/L	80 mg/L
COD	139 mg/L	148 mg/L	150 mg/L

Table 4:- Comparison of Untreated and Treated Effluents Using NEQS as Reference

Parameters		**TSS** (mg/L)	**TDS** (mg/L)	**TH** (ppm)	**Cl^-** (mg/L)	**SO_4^{--}** (mg/L)	**BOD_5** (mg/L)	**COD** (mg/L)
WHO Limits	**Desirable Levels**	150	3500	100	200	200	60	120
	Permissible Levels	200	5000	500	600	400	80	150
NEQS		150	3500	-	1000	600	80	150
Untreated Effluents	**Sample A**	187	4270	390	1366.8	688	88	196
	Sample B	195	3860	377	1486.8	656	96	224
Treated Effluents	**Sample A**	135	3450	390	886.2	505	66	139
	Sample B	146	3210	377	920.5	480	72	148

4. Conclusion

Treatment of effluents form the paper and pulp industries are essential to reduce environmental pollution. A cost effect technique using a gravimetric circular clarifier reduced BOD and COD levels by almost 25%. Hence, treated effluents after dilution with paper machine effluents will meet NEQS levels of 80 mg/l and 150 mg/l for BOD and COD respectively.

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