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Comparison of Active Sludge, Aquatic Ferns and Ozonation for Evaluation of COD, BOD and TOC in Treatment of a Combined Domestic and Industrial Wastewater Considering Color and Turbidity

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***Abstract*—** *Many biological absorbents have been used from algae, bacteria, fungi and etc. for purification. Aquatic ferns have the ability to remove contaminants both live and non-polluting, which due to its rapid growth on the surface of the water in aquatic areas in any country, as an invasive species, threatens the aquatic life and ecosystem of the regions. Also, many pollutants have been removed and recovered using active sludge from municipal sewage treatment plants as dry and active powder (alive). In addition, ozonation is one of ecologically clean perspective methods for the treatment of industrial and household wastewaters. In this research a comparison of using the three mentioned for treating a combined domestic and industrial wastewater was accomplished and the results showed remarkable removals in Biological Oxygen Demand, Chemical Oxygen Demand and Total Organic Carbon, as well color and turbidity of the considered wastewater was tested after the treatment and magnificent reductions in both were seen. After achieving the final data in all contaminants removal, aquatic ferns showed a better removal efficiency.*

***Keywords*—** *BOD, COD, Color, TOC, Turbidity, Wastewater Treatment.*

I. INTRODUCTION

Increasing worldwide population and variety of industrial means as well as decreasing natural resources of water and soil and climate change problems have risen international concerns. Unfortunately industrial growth has a deep adverse effect on environmental conditions while it improves human welfare [1]. Different categories of industries discharge various contaminants which are recalcitrant and non-biodegradable in most cases such as phenols, aromatics, dyes, nitrates and etc.

These pollutants can change environmental characteristics of natural resources that fresh up applications of modern environmentally friendly approaches for treatment strategies [2, 3]. There are fateful criteria namely health, hygiene, economy and food safety which are affected wildly by lack of water resources [4].

Besides reuse of polluted waters after treatment methods face difficulties while they are contaminated with recalcitrant heavy metals and their derivatives in various chemical and industrial processes which cannot be removed effectively [5, 6]. So application of a system which is environmentally friendly and economic is important. Therefore, application of ozone, active sludge and aquatic ferns were considered as advanced treatment methods and compared in this research.

The purpose of the biological treatment of industrial wastewater is to integrate and isolate insoluble colloidal materials and stabilize organic matter. In urban wastewater, the main objective is to reduce organic matter, toxic, heavy metals and biological mass [7].

The essential point in designing a biological purification process or selecting the type of process used is to understand the biochemical activity of microorganisms. Each organism must possess these factors for the survival and reproduction and proper function [8]:

- An energy source
- Carbon to synthesize new cell materials
- Mineral substances (nutrients) such as nitrogen, phosphorus, sulfur, potassium, calcium and magnesium

Among the chemical and physical and biological processes, the use of affordable biological absorbents in nature is very cost-effective, and even in some cases, the collection and use of it preserves the environment.

As the result of the adsorption process is the removal of one or more components of the fluid phase and its accumulation on the surface of an adsorbent, this method can be used to separate the components of a mixture or to separate some of the impurities from the desired fluid. Of course, the conditions of the adsorbent body and the conditions of the process should be selected and adjusted accordingly.

In the field of environmental studies, the most important application of this process is the treatment of urban and industrial wastewater. Because a large proportion of these waste products form pollutants can be easily separated by the adsorption process [9].

Reaching success in an absorption process depends on the choice of suitable adsorbent. Most of these adsorbents are selected among algae, fungi and bacteria. The first use of natural systems was introduced in Western Germany in the 1950s, which was later continued in various countries [10].

In this study, the active sludge from urban wastewater treatment plant and ferns as aquatic plants have been used as a non-volatile bioavailable, and obviously their use will also help the environment and then compared with the result of treatment by ozonation.

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II. Materials and Methods

First studying on ozonation, active sludge and aquatic ferns among combined domestic and industrial wastewater and their biological treatment was considered, and then how to remove the combinations derived by these three methods was practiced [11,12].

Since economic aspects are considered very important in wastewater treatment systems, and producing ozone because of its electrical costs seemed to be important, its low dosage and the limited time of ozonation that was spent in the treatment process was very important [13, 14], but after using aquatic ferns, the financial costs decreased dramatically and it proved the remarkable efficiency of such a method of treatment in comparison with the other two methods too.

In ozonation treatment for availability to a rate of impurity which is necessary for the ozone generator, the air which was used as the source of oxygen is treated and processed before anything else in order to be cleaned out of any fat, moisture, hydro carbons, and dust, although ozone`s productions are changeable by the much electrical current and regulating the air. Ozonated wastewater provides necessary substances for bio-treatment in both aerobic and anaerobic stages. For providing the essential substances for final biological treatment, sufficient solution which is ozonated wastewater is produced in some groups.

A simple reactor performance for treatment of model and real wastewater on laboratory and industrial scale was investigated for the active sludge and aquatic ferns usage. This refining process proceeded with special attention to the effect of solution pH-value, pollutant concentration, absorbent concentration and reaction time.

The batch industrial scale reactor represented over 90 % removal efficiency under pH-value of 6 and 5-5.5 for aquatic ferns and active sludge respectively. Effective reaction times represented various durations for ferns and active sludge with respect of 120 minutes and 90 minutes. The two biological masses had the best performances with 6 g/l for aquatic ferns and 5 g/l for active sludge. The effective factors in the adsorption process were as followings:

●The amount of mixing and mixing the fluid:

The speed of this process depends on the degree of mixing of the solution to one of the two stages of film diffusion and the pore diffusion. If the solution is sufficiently stirred, the thickness of the soluble layer is reduced to the absorber surface and the molecule of the absorbing component reaches the absorbent surface very quickly. In these conditions, the velocity of the second stage (inside the pore diffusion) will play a controlling role. Usually, in these systems, we are faced with discontinuities.

●Type and Characteristics of the Absorbent Body:

The most important attraction property is the total area of its outer surfaces. Usually, objects have a lot of pores on their surface. Therefore, as the adsorbent body is divided into smaller parts, its contact surface is increased with the fluid phase (the absorbing component), resulting in greater process speed.

●Size of the molecules of the absorbing component:

To absorb the molecule, it is necessary that the diameter of the molecule is less than the diameter of the pores on the surface of the adsorbent. The smaller the molecule, the easier it is to penetrate into the absorbent pore.

●pH Operating Environment:

Due to the fact that their H^+ ions have a significant absorption capacity, the environment is effective at the process speed and absorption rate. Therefore, for each specific system, the best conditions should be determined in terms of pH by performing tests.

●Operating temperature:

Depending on whether the adsorption phenomenon is of a physical or chemical nature, the temperature rise of the system will have different effects on the absorption rate. If the adsorption is of a physical type, the temperature increase will reduce absorption, and if the absorption is of a chemical type, the temperature increase will increase the absorption rate.

III. Results And Discussion

Comparison of Biological Oxygen Demand and Chemical Oxygen Demand Removals by the three methods

As it can be seen in table I the content of BOD and COD in all the three wastewater treatment methods is presented. The very brilliant point is that although in all the methods the removal has a significant decreasing trend, the removal trend in treatment method with aquatic ferns showed a very remarkable decline in all the six steps of the treatment process. After recording the achieved data it is seen that the BOD was almost half in amount in all the 6 steps by the treatment by aquatic ferns in comparison with the simple treatment while a two third reduction in treatment with active sludge was recorded and the contents of both BOD and COD with treatment by ozonation were approximately between these two.

TABLE I. Concentration of BOD and COD in the output wastewater with ozonation, aquatic ferns and active sludge

STEPS	Treated Effluent by Biological Method		Treated Effluent by Active Sludge		Treated Effluent by Ozonation		Treated Effluent by Aquatic Ferns	
	BOD (g/m^3)	COD (g/m^3)	BOD (g/m^3)	COD (g/m^3)	BOD (g/m^3)	COD (g/m^3)	BOD (g/m^3)	COD (g/m^3)
1	110	190	70	101	65	80	60	68
2	85	182	50	97	45	77	40	70
3	50	162	34	86	32	58	24	43
4	60	150	35	78	29	49	25	38
5	50	138	36	60	28	38	26	27
6	48	126	35	53	27	31	25	25

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Comparison of Total Organic Carbon by the three methods

Also the TOC content had a magnificent reduction after the usage of the advanced mentioned treatment methods where Total Organic Carbon from 58, 50, 48, 53, 55 and 49 mg/l after the biological treatment changed to 50, 44, 41, 49, 48 and 42 mg/l with treatment by active sludge, 47, 39, 36, 42, 40 and 37 mg/l with ozonation treatment and 41, 34, 31, 37, 34 and 31 mg/l with treatment by aquatic ferns respectively.

TABLE III. Concentration of TOC in the output wastewater with ozonation, aquatic ferns and active sludge

STEPS	Treated Effluent by Biological Method	Treated Effluent by Active Sludge	Treated Effluent by Ozonation	Treated Effluent by Aquatic Ferns
	TOC (mg/l)	TOC (mg/l)	TOC (mg/l)	TOC (mg/l)
1	58	50	47	41
2	50	44	39	34
3	48	41	36	31
4	53	49	42	37
5	55	48	40	34
6	49	42	37	31

For the recorded data regarding the BOD, COD and TOC content, the Biological Oxidation Conditions were as followings:

PH= 7.08-8.05 / Temperature=22-25.5 Degree Centigrade

And the Bio-Ozone-Bio Oxidation Conditions were as followings:

PH= 8.06-8.9 / Temperature=22-25.5 Degree Centigrade

Comparison of Color and Turbidity by the three methods

Color and turbidity are two very vital factors in any wastewater treatment system. Bacteria, viruses and parasites such as giardia and cryptosporidium can attach themselves to the suspended particles in turbid water.

These particles then interfere with disinfection by shielding contaminants from the disinfectant. Color is an organic material that has dissolved into solution, while turbidity consists of tiny particles suspended in the water column. It is the organic material in the watershed that causes both color and turbidity.

Using the aquatic ferns in comparison with the two other systems for the treatment of the considered wastewater showed a much better result in both color and turbidity where 64.3 (Pl-co) in comparison with 75.6 and 95.3 (Pl-co) for treatment with ozonation and active sludge respectively were resulted in color and 25.4 (NTU) in comparison with 30.1 and 39.4 (NTU) were recorded respectively.

TABLE IIIII. Color and Turbidity Content in the Treated Effluent by Active Sludge, Ozonation and Aquatic Ferns

Average of Treated Effluents	Color (Pl-co)	Turbidity (NTU)
Average of Treated Effluent by Biological Method	128.84	45.38
Average of Treated Effluent by Active Sludge	95.3	39.4
Average of Treated Effluent by Ozonation	75.6	30.1
Average of Treated Effluent by Aquatic Ferns	64.3	25.4

IV. CONCLUSION

Regarding to the ease of penetration of organic pollutants to water, soil and different parts of environment, application of clean technologies for purification is recommended. The importance of any treatment process is clarified via ease of availability, deep performance, economic influences and low sludge waste volume which all are included in the aforementioned treatment process by aquatic ferns, active sludge and ozonation where aquatic ferns presented more efficient results in comparison with the two other. Dispersion of aquatic ferns in the wastewater at agitation speed of 50 rpm provided a suitable environment in BOD, COD and TOC removal as well as color removal and turbidity reduction.

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