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Using of Activated Carbon Adsorption in Wastewater Industries

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ABSTRACT

Use of activated carbon in waste water treatment is not a new idea, therefore since 1935 experience has been gained in its use to increases the coagulation and flocculation of solids, anaerobic digestion of sludge and for removal of water from it. Experience has shown that activated carbon powder as an additive at the time of addition of hydraulic load of waste water, results in the compression of sludge and facilitates the removal of water from it. In these experiments the usefulness of Powered Activated Carbon (PAC) is determined, but due to economical and the fact that high degree of treatment was not required, this was not fully accepted. In the past use of Granular Activated Carbon (GAC) was more popular compared to its powered type, and it also had higher efficiency. In this article, initially a literature review of work done on the use of Activated Carbon Powder and the trend of growth in its use and the modifications made during last few years in the world and Iran and finally various experiments performed on activated carbon pilot unit at one of the petro-chemical units in Iran, in order to analyze the usefulness of this material in waste water treatment. In addition, two type of commercial activated carbon powder were used from two different suppliers giving different results, the reason for these different results was also analyzed and this difference in result was attributed to different constituents. For every experiment 4kg of activated carbon was used in the pilot plant column. The samples for experiment were taken from the exit stream from the clarifier. Results were obtained for effect of parameters such as inlet volumetric flow rate of waste water and activated carbon structure on its performance.

1. Introduction

Today, the requirements of growing population and healthy environment away from the infections are more and more evident. Efforts to combat environmental contamination factor is the most important human activities today [1-5]. One of the most important factors in water contamination is sewage and waste water. Untreated sewage per cubic meter contaminated the amount of water resources heavily [6-10]. Over 99.9 percent of the sewage water is contains water, but the same small amount of solids in the sewage makes an important effect on the environment. Unfortunately, Citizens and industrial increased not only increase the amount of water, but also the amount of water pollution has been increased [11-14]. Especially over time due to the use of hundreds of chemical products in daily life and entering the wastewater and urban sewage discharge or consumer bodies and discharge of thousands of new chemical compounds in their industries and river, the water pollution has become more sophisticated [15-20]. As you know water provides the human free of charge and the simplest way for waste transmission in communities. Considering the increased public concern about the effects of new combinations of organic on human environment in the past decade, the need for more advanced treatment process to reduce pollutants and remove materials, especially materials that were not deleted in common important processes like biological, physical and chemical properties [21-24]. Among the improved methods, the powdered activated process in carbon activated sludge unit air is used. However, this method first was used for increasing efficiency activated sludge removal system known as priority pollutants, but then has a variety of applications [25-29]. Due to the above process in an appropriate stability system

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performance, remove the desired organic material and color, reduce the massive mud, remove the foam and others, now is the increasing acceptance. We established limited sewage treatment plants, we have control problems and failure involved in exploitation of the above facilities, sometimes without doing the necessary studies and researches have been designed so that efficiency advantage of them not very desirable. Therefore, adding activated carbon powder can be useful in refineries [29-34].

2. Absorption Theory

Absorption in a two-phase system liquid - solid to remove materials from their solution in the liquid phase and concentrate them in the solid surface, always balance reaches a certain state that certain distribution of matter between liquid and solid phase in this case is obtained. The equilibrium equation of the temperature absorption mode is used, described. Absorption isotherm, a kind of mathematical explanation and concentration dependence of absorption material in absorbed temperature is constant. Usually the absorbing material concentration in liquid phase increased the amount absorbed per unit weight and concentration of absorbing material in the same equilibrium solution is fixed in the isothermal absorption temperature [35-38]. Absorption isotherm equation usually assume a layer of molecules absorbed on the surface material in absorbent or states are more complex to achieve [39-42]. In 1918 to describe the level of absorption of the gas phase solid related isotherm was presented by Longmir that he based on studies using simple thermodynamic conditions Kinetics led to the equation. He based his work on the hypothesis that single-layer absorbing energy absorption of fixed and any transfer of material to absorb [43-45]. He believed that the number of absorption pulses to attract empty areas depends on concentration of absorbing material in the fluid phase. While the number of desorption pulses occupied areas depends on absorption [46-49].

$$\frac{X}{M} = \frac{abC_e}{1 + bC_e}$$

In this equation:

$\frac{X}{M}$: Value per unit weight of the sorbent which absorbed.

a ,b : Empirical constants

C_e: Concentration of absorbing material in balanced solution absorption after operation

Langmir model is based on many assumptions that it's application in various fields and especially in the sewage can be faced with many problems. Frndlych in 1926 provide empirical equation between the amounts of C_e and $\frac{X}{M}$ can be connected again. Despite these empirical equations, isotherm results obtained with the highest coordination of works shows in water and sewage.

$$\frac{X}{M} = KC_e^{\frac{1}{n}}$$

In this equation:

$\frac{X}{M}$: Value per unit weight of the sorbent which absorbed.

K, n : Empirical constants

C_e: Concentration of absorbing material in balanced solution absorption after operation

K, n can be drawn and the values on paper by hand to determine the following:

$$\log\frac{X}{M} = \log K + \frac{1}{n}\log C_e$$

Except above isotherm, other people also presented other equations which have been mentioned in other forms of relations. In absorption process, reaction interacted between fluid and solid phase, so any studies in this field are including the two-phase properties. Several studies show that such absorption is a surface process, therefore first, active surface area for absorbing the amount of the surface absorption is available, is direct on speed and intensity of absorption. The reduction of Article solubility and absorption increase its molecular mass, the rate of absorption will be increase. Environment PH also affects the absorption. Decreasing pH in many cases improved absorption on activated carbon. The temperature increase due to reduced viscosity, accelerate absorption process, but the absorption reduced. Since the absorption is a surface phenomenon, so all of substances which have many active weight unit, can used in different industries and absorbing water and wastewater. One of the most well-known absorptions current is activated carbon. This material Crystal and other fine form of carbon graphite is to develop and increase the porosity, the process has been computed [50]. Active carbon with specific surface area, special features about 300-2500 square meters per grams, have been described which this features the ability of physical adsorption of gases and steam from the gases and dissolved substances and fluids released. Activated carbon is the most common absorber that use in water purification and sanitation. This material produced from carbonaceous materials such as wood, coal, waste oil and etc. [51]. Coal produced by burning the articled without air. The coal is then oxidized at higher temperatures to establish very porous structure. This activation step, irregular channels and pores created a solid mass and cause very large ratio of surface area to mass. Types of commercial activated carbon as absorbent and gas phase or liquid phase have been designed. Liquid phase of carbon generally used as powder or grain [52]. With this article, process can remove organic matter or mineral flow of gas, water and sewage and industrial liquids. Absorption process on carbon is usually reversible so resuscitation saturated carbon is relatively simple. due to nonspecific activated carbon, this material can be very effective absorbent in different processes like paint removing, odor removing, remove circular aromatic compounds, absorption of chlorine and toxic substances in air, filtration or remove inorganic mineral salts, separation, concentration of salts, recycling valuable materials and many other use cases [53]. Considering the widespread use of activated carbon in various food industries - chemical - pharmaceutical and est. the material world consumption per capita is very high that average use in America is 0.4, Japan 0.5, Western Europe 0.2 and other parts of the world 0.3 kg per person a year. Total production of activated carbon in 1978 was equivalent to 220,000 tons which more than 80 percent use for liquid phase in grain of powder form of activated carbon [54]. According to application type, different forms of activated carbon produced. This material can be based on the activity level, the behavior and could classify on properties of absorption and shape. According to shape and size, particles of active carbon are divided into powder, grain and pellets [55]. If between 65 to 90 percent of the particles pass through sieve mesh 325, it called powder and if the average particle diameter be 200 microns, the carbon calls grain [56-58].

2-1. Tests

After numerous experiments on the leading units' available activated carbon as the leading unit, the flow volume of effluent discharge changes the input parameters on the performance results were measured. In experiments two types of activated powder carbon of Pajohan Chimi Co. Ltd. and petrochemical industry spare parts and chemical substances (SPEC) has been used and their specifications collected in Table (1).

The tests used in the leading column with internal diameter $D = 0.15m$ and height $H = 1.2m$.

Total volume of the column is:

$$V = \frac{\Pi}{4} D^2 H = \frac{\Pi}{4} (0.15)^2 (1.2) = 0.021m^3$$

With inner diameter of the towers $D = 0.15m$, internal tower area is:

$$A = \frac{\Pi}{4} D^2 = 0.0176m^2$$

The rate of 4 kg of activated carbon entered to column. In these tests activated carbon powder of engineering design and manufacturing company supplying parts and chemicals Petrochemical (SPEC) has been used. According to reads the height $H' = 1.1m$, active volume and the accumulated active carbon column is:

$$V' = \frac{\Pi}{4} D^2 H' = \frac{\Pi}{4} (0.15)^2 (1.1) = 0.019m^3$$

The experimental method in this column are the effluent samples pump from tank using the clear effluent samples from the first poster (A-5505) and clear the second poster (A-5506) filled with wastewater treatment plant of Shahid Tondgoyan petrochemical company, Inlet to a rotameter flow meter that effluent discharge rate changed by a normal valve. Effluent output of rotameter sends to the column and discharged after crossing the layers of activated carbon. Effluent samples sent to the laboratory for the study is.

Table 1. Profile activated carbon used in express unit

Row	characteristic	Value (Pajohan Chimi Co.)	Value (SPEC Co.)	Measurement Unit
1	Special surface	1010	1050-1300	m^2 / gr
2	Iodine index	1000	900-1000	mg / gr
3	particles Diameter	40	40	μm
4	pH	6-7	6-7	-
5	ash	5-6	2.5	Wt%
6	moisture	10	3	Wt%
7	Density	0.75	0.7	gr / cm^3

A: Effluent discharge input:

$$Q = 0.5 \frac{m^3}{hr} = 1.388 \times 10^{-4} \frac{m^3}{S}$$

Speed inside the column effluent is:

$$u = \frac{Q}{A} = \frac{1.388 \times 10^{-4}}{0.0176} = 7.891 \times 10^{-3} \frac{m}{S}$$

Remained effluent time inside the column is:

$$t = \frac{V}{Q} = \frac{0.021}{1.388 \times 10^{-4}} = 47.25S$$

Remained effluent time in contact with activated carbon is: $t' = \frac{V'}{Q} = \frac{0.019}{1.388 \times 10^{-4}} = 42.75S$

The results of tests made on activated carbon for both companies listed specific discharge collected in Tables (2) and (3).

Table 2. Changes caused by COD using activated carbon SPEC Company with effluent flow rate:

$$Q = 0.5\frac{m^3}{hr} = 1.388\times10^{-4}\ \frac{m^3}{S}$$

Date	First clarifier (COD_{in})	First clarifier (COD_{out})	Difference	Second clarifier (COD_{in})	Second clarifier (COD_{out})	Difference
2021/09/11	1300	720	50	320	190	130
2021/09/12	1150	630	520	280	160	120
2021/09/13	1050	570	480	260	145	115
2021/09/14	1300	720	580	250	140	110
2021/09/15	1100	610	490	350	210	140

Table 3. Changes caused by COD using activated carbon Pajohan Chimi Co.with effluent flow rate:

$$Q = 0.5\frac{m^3}{hr} = 1.388\times10^{-4}\ \frac{m^3}{S}$$

Date	First clarifier (COD_{in})	First clarifier (COD_{out})	Difference	Second clarifier (COD_{in})	Second clarifier (COD_{out})	Difference
2021/09/18	1490	950	540	640	370	270
2021/09/19	1600	1000	600	740	450	290
2021/09/20	1380	890	490	650	375	275
2021/09/21	970	680	290	330	105	225
2021/09/22	1020	700	320	570	310	260

B: Effluent discharge input: $Q = 0.3\frac{m^3}{hr} = 1.388\times10^{-4}\ \frac{m^3}{S}$

Speed inside the column effluent is: $u = \frac{Q}{A} = \frac{8.333\times10^{-5}}{0.0176} = 4.734\times10^{-3}\ \frac{m}{S}$

Remained effluent time inside the column is: $t = \frac{V}{Q} = \frac{0.021}{8.333\times10^{-5}} = 189S$

Remained effluent time in contact with activated carbon is: $t' = \frac{V'}{Q} = \frac{0.019}{8.333\times10^{-5}} = 171S$

The results of tests made on activated carbon for both companies listed specific discharge collected in Tables (4) and (5).

Table 4. Changes caused by COD using activated carbon SPEC Company with effluent flow rate:

$$Q = 0.3\frac{m^3}{hr} = 1.388\times10^{-4}\ \frac{m^3}{S}$$

Date	First clarifier (COD_{in})	First clarifier (COD_{out})	Difference	Second clarifier (COD_{in})	Second clarifier (COD_{out})	Difference
2021/09/11	1300	670	630	320	165	155
2021/09/12	1150	600	550	280	115	165
2021/09/13	1050	550	500	260	100	160
2021/09/14	1300	670	630	250	95	155
2021/09/15	1100	580	520	350	185	165

Table 5. Changes caused by COD using activated carbon Pajohan Chimi Co. with effluent flow rate:

$$Q = 0.3\frac{m^3}{hr} = 1.388\times10^{-4}\frac{m^3}{S}$$

Date	First clarifier (COD_{in})	First clarifier (COD_{out})	Difference	Second clarifier (COD_{in})	Second clarifier (COD_{out})	Difference
2021/09/18	1490	875	615	640	325	315
2021/09/19	1600	915	685	740	385	355
2021/09/20	1380	810	570	650	320	330
2021/09/21	970	605	365	330	90	240
2021/09/22	1020	645	375	570	275	295

C: Effluent discharge input: $Q = 0.1\frac{m^3}{hr} = 2.777\times10^{-5}\frac{m^3}{S}$

Speed inside the column effluent is: $u = \frac{Q}{A} = \frac{2.777\times10^{-5}}{0.0176} = 1.578\times10^{-3}\frac{m}{S}$

Remained effluent time inside the column is: $t = \frac{V}{Q} = \frac{0.021}{2.777\times10^{-5}} = 756S$

Remained effluent time in contact with activated carbon is: $t' = \frac{V'}{Q} = \frac{0.019}{2.777\times10^{-5}} = 684S$

The results of tests made on activated carbon for both companies listed specific discharge collected in Tables (6) and (7).

Table 6. Changes caused by COD using activated carbon SPEC Company with effluent flow rate:

$$Q = 0.1\frac{m^3}{hr} = 2.777\times10^{-5}\frac{m^3}{S}$$

Date	First clarifier (COD_{in})	First clarifier (COD_{out})	Difference	Second clarifier (COD_{in})	Second clarifier (COD_{out})	Difference
2021/09/11	1300	510	790	320	110	210
2021/09/12	1150	400	750	280	80	200
2021/09/13	1050	345	705	260	65	195
2021/09/14	1300	510	790	250	50	200
2021/09/15	1100	390	710	350	130	220

Table 7. Changes caused by COD using activated carbon Pajohan Chimi Co.with effluent flow rate:

$$Q = 0.1\frac{m^3}{hr} = 2.777\times10^{-5}\frac{m^3}{S}$$

Date	First clarifier (COD_{in})	First clarifier (COD_{out})	Difference	Second clarifier (COD_{in})	Second clarifier (COD_{out})	Difference
2021/09/18	1490	810	680	640	260	380
2021/09/19	1600	850	750	740	315	425
2021/09/20	1380	755	625	650	255	395
2021/09/21	970	560	410	330	60	270
2021/09/22	1020	590	430	570	215	355

4. Conclusion

The results of Examination of the experiments obtained are the following:

1) Activated carbon has no significant effect on effluent flow pH.

2) When the wastewater treatment system shock with high COD in incoming effluent from PTA and PET units, activated carbon can reduce the amount of COD which absorb pollution, carbon saturated burned in waste incineration furnace.

3) Because the required mass of activated carbon per cubic meter of effluent (COD 2000-300 range), according to the references provided 0.5 kg, Therefore, the first and second air basins according to their volume, amount of activated carbon required is:

4) Reduced discharge effluent flow rate to the activated carbon column due to more time during the stay, output COD rate decreases further. This entry shown in Charts 1 to 4.

5) SPEC Company's Activated carbon has further ability to reduce COD than Pajohan Chimi Company. This compared observed well with charters 5 and 6. . Algebraic comparing of Trendline slope recognized that with SPEC Company's activated carbon, ratio of absorbed pollution is more.

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