BOD: COD Ratio as Indicator for Wastewater and Industrial Water Pollution

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ABSTRACT: The relationship between the biochemical oxygen requirement (BOD) and the chemical oxygen requirement (COD) for wastewater / University of Basrah / Garmat Ali and industrial water / Najibiya power station was studied. Chemicals were used as coagulants (Polyacrylamide, anionic and cationic) with different concentrations, as well as aluminum sulfate(alum,), ferric chloride and sodium hydroxide in different concentrations. The results showed that BOD: COD ratio can be used as a good indicator for measuring water pollution, and it can also be used as an indicator to predict the relationship between BOD and COD, as well as knowing the organic matter content in wastewater and industrial water. The results showed that BOD: COD ranged between 0.33-0.89 and seeding is required to treat it biologically**.**

Keywords: BOD, COD, Ratio, Wastewater, Industrial Water Pollution

INTRODUCTION

Organic matters are usually quantified as BOD (Biochemical Oxygen Demand) and COD (Chemical Oxygen Demand) while inorganic matters are mainly quantified as sulfate, chloride, ammonium, heavy metals and others (Lee & Nikraz,2014). BOD and COD are important measurements to determine the extent of water pollution (Mouri, Takizawa, 2011). The ratio of BOD: COD indicates the biodegradability of wastewater, the higher value of BOD: COD value means low biodegradability of water (Papadopoulos *et al.*, 2001). When the ratio of BOD:COD is less than 0.1, which means the presence of high organic matter and is it difficult to biodegrade, and it can be toxic (Andrio *et al.*,2019) The lowest ratio of BOD:COD for water to be easily biodegradable is 0.4 (Lee & Nikraz,2015) and that the best value is greater than 0.5 (Samudro & Mangkoedihardjo,2010).

Different chemicals were used to reduce the concentrations of organic substances in water to reduce its danger and be environmentally safe (Al-Rosyid & Mangkoedihardjo, 2019). The purpose of this study to use different chemicals with different concentrations to reduce the concentrations of organic substances in water and predict the amount of organic pollution by measuring the BOD ratio: COD.

Key words: BOD, COD, BOD:COD ratio, Wastewater treatments

MATERIALS & METHODS

Wastewater samples were collected by plastic containers from wastewater plant affiliated to Basrah University in Garmat Ali and the other from industrial water affiliated to the General Company for Electricity Production for the Southern Region / Steam Generating Stations Department/Najibia Power Plant and kept in the refrigerator at 4°C

The biological oxygen requirement (BOD) was measured by the difference between the two dissolved oxygen concentrations before and after incubation estimated according to (Azide Modification) method described in (2017) Baird *et al*.,2017. The chemical oxygen requirement (COD) was also measured according to the Dichromate reflux method described in Baird *et al*., (2017), which is based on heating the sample in the presence of a standard potassium dichromate mixture. The Ratio BOD: COD were calculated for all treatments before and after wastewater treatment with chemicals.

RESULTS & DISCUSION

BIOCHEMICAL OXYGEN DEMAND(BOD)

The results of the statistical analysis (Table 1) showed that there were significant differences in the value of BOD in sewage and industrial water samples. The zeolite mineral achieved a significant decrease in the value of BOD by 22.74%, this is due to its high cationic exchange capacity, which led to adsorption and chelating of organic compounds and decrease it in water. The addition of polymers led to a significant decrease in the value of BOD, with decrease rates ranging from 19.01% to 41.71%, respectively. This is due to the role of polymers in the coagulation process, where they accumulate colloidal particles in the form of colloids through the opposite charge that polymers have,

such as the charge of organic and colloidal substances in water, and then followed by the flocculation process and formation of large particles or large aggregates (Kerri,2002).

Using of alum caused a significant decreasing in the value of BOD with a percentage 37.79 % and 39.61 %. This is due to the dissolution of alum in water and produce aluminum hydroxide $AL(OH)_3$, which accumulate suspended materials in water such as clays and organic materials, and then increases in size and facilitates its precipitation (Jagaba et al.,2018).

The addition of ferric chloride led to a significant decrease in the value of BOD, with a decreasing percentage between 27.40% and 24.18%. This is due to the dissolution of ferric chloride in water, which forms the ferric hydroxide compound $FeCl_3$, which is one of the coagulants in water treatment, as it forms gelatinous materials from ferric hydroxides, which in turn are a adsorbent for organic colloids (Abdalla & Hammam,2014).

Using of sodium hydroxide decreased the value of BOD, but at a lower percentage than the other coagulants, and the percentages of decrease ranged between 18.13 and 15.42%. Where bacteria usually oxidize organic carbon in polluted water and produce carbon dioxide, and when sodium hydroxide is added, it will combine with carbon dioxide to form sodium carbonate. The process of mixing chemicals led to a significant decreasing in the value of BOD, especially the treatments containing polymers. As for the treatments containing alum or NaOH, the BOD value raised, and the reason for this is due to the nature of the chemical reactions that take place between the analysis products from dissolution and interaction between them, which produces compounds that reduce the efficiency of the active substance and the coagulant if used alone

Treatments	Type of water		Mean
	Wastewater Basrah University	Industrial water Najibia Power Plant	
Primary water(control)	231.5	197.7	214.6
Zeolite	177	154.7	165.8
Anionic-PAM(50mg l^{-1})	192.7	155	173.8
Anionic-PAM(100 mg l^{-1})	166	148	157
Cationic- PAM(50mg l^{-1})	130.1	120.6	125.1
Cationic-PAM(100mg l^{-1})	183.3	162	172.7
Alum(50 mg l^{-1})	115.3	151.7	133.5
Alum(100 mgL^{-1})	131.6	127.1	129.6
NaOH(4gm l^{-1})	186.6	165	175.7
NaOH(8gm L^{-1})	191.9	171	181.5
$FeCl_3$(20 mgL^{-1})	160	152	155.8
$FeCL_3$(40 gm L^{-1})	167.7	157.3	162.7
Anionic -PAM(50 mgL^{-1})+Cationic PAM(50 mgL^{-1})	178	155.7	166.8
Anionic- PAM(50 mg l^{-1}) + Alum(50 mg l^{-1})	155.8	153.3	154.9
Cationic - PAM(50 mg l^{-1}) + Alum(50 mg l^{-1})	142.1	138	140
Anionic- PAM(50 mg l^{-1}) + $FeCl_3$(50 mg l^{-1})	157.1	150	153.7
Cationic- PAM(50 mg l^{-1}) + $FeCl_3$ (50 mg l^{-1})	155	147.9	151.5
Alum(50 mg l^{-1})+ $FeCl_3$(20 mg l^{-1})	163	159	161
Anionic-PAM(50 mgl^{-1})+ NaOH(4gm l-	173.3	161.1	167.3

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Cationic-PAM(50 mg l^{-1})+ NaOH(4gm L^{-1})	161	158	159.3
Alum(50 mg l^{-1})+ NaOH(4gm L^{-1})	175	166.5	171.3
$FeCl_3$(20 mg l^{-1})+ NaOH(4gm L^{-1})	180	173	176.3
R.L.S.D(0.05) 26.9			R.L.S.D(0.05)= 18.5
Mean	16.7	15.57	Mean=161.4
	R.L.S.D(0.05)= 4.5		

Table 1: Effect of chemical on BOD (mg l^{-1}) value of wastewater and industrial water

CHEMICAL OXYGEN DEMAND (COD)

The results of statistical analysis (Table 2) showed that there were significant differences in the value of COD in wastewater and industrial water samples. The addition of zeolite led to a significant decrease in the value of COD by 33.87%. This is due to the chemical composition of zeolite composition and its high cation exchange capacity which led it to adsorb organic matter by bridging mechanisms. Ospanov *et al.* (2016) found that the efficiency of zeolite in decreasing COD value of wastewater was 89.65%.

The addition of alum led to a decrease in the value of COD. 39.47% and 44.86%. This is due to the hydrolysis of alum and formation of positively charged aluminum hydroxides, $AL(OH)^{+}$ which interact with negatively charged organic compounds and decrease COD (Ramadan *et.al.*, 2017).

The polymers had a significant decrease in the value of COD as compared with other materials used as coagulants, the decreasing was ranged between 62.23% to 71.79%. This is due to high molecular weight of polymer and have many organic groups with positive and negative charges, which have the ability to adsorb and do chelation reaction with organic materials (Exall *et al*., 2008).

The addition of ferric chloride led to a significant decrease in the value of COD by 38.57% and 43.34%. This is due to the formation of gelatinous materials from ferric hydroxides, which in turn are considered to adsorb organic colloids, which determines its efficiency on its concentration and water pH (7-4) (Sahu & Chaudhari,2013).

Sodium hydroxide (NaOH) led to decrease in the value of COD, but by a lower percentage than that of the other coagulants, and the percentage of decrease ranged between 30.80% and 26.80%. That is due to sodium hydroxide led the water alkaline and precipitate some ions and ionize the active groups of organic materials and let had a negative charge and their association with sodium ions and their precipitate in solution, which decrease COD in water (Sharma and Sharma, 2014).

Table 2: Effect of chemical on COD values (mg l^{-1}) of wastewater and industrial water

Treatments	Type of water		Mean
	Wastewater Basrah University	Industrial water Najibia Power Plant	
Primary water(control)	521.83	750.23	636.03
Zeolite	299.93	541.07	420.5
Anionic-PAM(50mg l^{-1})	176.1	212.6	194.3
Anionic-PAM(100 mg l^{-1})	195.2	285.2	240.2
Cationic-PAM(50mg l^{-1})	178.13	180.7	179.42
Cationic-PAM(100mg l^{-1})	172.7	288.5	230.6
Alum(50 mg l^{-1})	285.8	484.2	385
Alum(100 mgL^{-1})	290.7	410.7	350.7
NaOH(4gm l^{-1})	295.3	585.1	440.2
NaOH(8gm L^{-1})	310.6	620.6	465.6
$FeCl_3$(20 mgL^{-1})	280.6	500.8	390.7
$FeCL_3$(40 gm L^{-1})	320.6	400.22	360.41
Anionic -PAM(50 mgL^{-1})+Cationic PAM(50 mgL^{-1})	196.3	285.6	240.9
Anionic-PAM(50 mg l^{-1}) + Alum(50 mg l^{-1})	250.1	390.1	320.1
Cationic -PAM(50 mg l^{-1}) + Alum(50 mg l^{-1})	100.77	399.43	250.1
Anionic-PAM(50 mg l^{-1}) + $FeCl_3$(50 mg l^{-1})	440.8	290.1	365.45

Cationic-PAM(50 mg l^{-1}) + $FeCl_3$ (50 mg l^{-1})	360.7	280.83	320.77
Alum(50 mg l^{-1})+ $FeCl_3$(20 mg l^{-1})	333.6	408	370.8
Anionic-PAM(50 mgl^{-1})+ NaOH(4gm l^{-1})	220.33	561.07	390.7
Cationic-PAM(50 mg l^{-1})+ NaOH(4gm L^{-1})	320.53	409.87	365.2
Alum(50 mg l^{-1})+ NaOH(4gm L^{-1})	240.53	530.87	385.7
$FeCl_3$(20 mg l^{-1})+ NaOH(4gm L^{-1})	200.43	553.37	376.9
R.L.S.D(0.05)= 0.96			R.L.S.D(0.05)= 0.68
Mean	272.34	425.87	Mean=349.104
	R.L.S.D(0.05)= 0.22		

BOD:COD ratio

BOD and COD are used to determined organic pollutants presents in water, it is of paramount parameter to determine the correlation of BOD and COD for measurement of pollutants in the water it called biodegradability index (BI). Table 3 showed the BOD:COD ratio of wastewater and industrial water before and after treated with chemicals, the values of BOD:COD ratio were between 0.3(Control, wastewater) to 0.89 (anionic-PAM at 50 mg l^{-1}). It is noted that the BOD:COD ratio for all treatments were less than 1. According to Mtui (2001) decrease in COD accompanied by an increase in BOD will increase the ratio of BOD:COD waste. Large BOD:COD ratio indicate that the substance has enough carbon to degrade. Assessment of biodegradability index values periodically, and comparing it to the mean B.I. for the particular wastewater treatment plan can assist in monitoring the pretense of toxic and non-biological wastewater treatment plant technology, it is important to know the biodegradability index of the raw influent wastewater, as this choice would considerably affect the plant effluent quality .If BOD:COD>0.6 then the waste is fairly biodegradable, and can be effectively treated biologically. If BOD:COD ratio is between 0.3 and 0.6, then seeding is required to treat it biologically, because the process will be relatively slow, as the acclimatization of the microorganisms that help in the degradation process take time. If BOB:COD ratio<0.3, biodegradation will not be proceeded, thus it cannot be treated biologically, because the wastewater generated from these activities inhibits the metabolic activity of bacterial seed due to their toxicity or refractory properties. (Samudro &Mangkoedihardjo,2010). According to B.I. table 3 showed the values of BOD:COD ratio were between 0.3 to 0.6 (accept, anionic-PAM (50 and 100mg l^{-1}), cationic-PAM (50 and 100 mg l^{-1}) seeding is required to treat it biologically.

Table 3: BOD:COD ratio of wastewater and industrial water

Treatments	BOD/COD
Primary water(control)	0.33
Zeolite	0.39
Anionic-PAM(50mg l^{-1})	0.89
Anionic-PAM(100 mg l^{-1})	0.65
Cationic- PAM(50mg l^{-1})	0.69
Cationic- PAM(100mg l^{-1})	0.74
Alum(50 mg l^{-1})	0.34
Alum(100 mgL^{-1})	0.36
NaOH(4gm l^{-1})	0.39
NaOH(8gm L^{-1})	0.38
$FeCl_3$(20 mgL^{-1})	0.40
$FeCL_3$(40 gm L^{-1})	0.45
Anionic -PAM(50 mgL^{-1})+Cationic PAM(50 mgL^{-1})	0.69
Anionic- PAM(50 mg l^{-1}) + Alum(50 mg l^{-1})	0.48
Cationic - PAM(50 mg l^{-1}) + Alum(50 mg l^{-1})	0.55
Anionic- PAM(50 mg l^{-1}) + $FeCl_3$(50 mg l^{-1})	0.42
Cationic- PAM(50 mg l^{-1}) + $FeCl_3$ (50 mg l^{-1})	0.47
Alum(50 mg l^{-1})+ $FeCl_3$(20 mg l^{-1})	0.43
Anionic-PAM(50 mgl^{-1})+ NaOH(4gm l^{-1})	0.43
Cationic-PAM(50 mg l^{-1})+ NaOH(4gm L^{-1})	0.44
Alum(50 mg l^{-1})+ NaOH(4gm L^{-1})	0.44
$FeCl_3$(20 mg l^{-1})+ NaOH(4gm L^{-1})	0.46

CONCLUSION

The conclusions obtained from this study are, the values of BOD:COD ratio varied between 0.33 to 0.89 seeding is required to treat it biologically. As a result, the BOD:COD ratio can be categorized into toxic, biodegradable and acceptable or stable zones. Wastewater treatments decrease BOD:COD ratio, one may identify the treatment strategy to achieve the safe levels of organic matter in an environment

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