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Investigation of a Modified Treatment Method of Industrial Wastewater in GIAD Factory

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Abstract

This study aims at solving the pollution problem in one of the industrial factories of GIAD manufacturing chemical compound. For dealing with this problem, a lab scale wastewater has been designed to recycle water. To extract the dissolved Na2SO4 and NaNO3, raw materials (activated charcoal, Na_2SO_4, $NaNO_3$, two gas cylinders of H_2 and CO were used. The experiments were prepared and carried out by mixing charcoal with water which contains Na_2SO_4 & $NaNO_3$ and adding mixtures of gases containing (CO and H_2) inside conical flask under temperature of 35°C. Three tests at different times were performed. Each test consisted of five results which were read and tabulated and three flowcharts were plotted from the obtained data. A process is described whereby sulphate is reduced to sulfide. Nitrate was converted to ammonia in the anaerobic reactor. From the obtained results the lab scale plant was scaled up to industrial size as a solution for the main problem. So it is highly recommended to construct the designed treatment plant to purify the wastewater station

Keywords: Waste water, Heavy metal, *Calotropis procera*, and Phytoremediation

Introduction

The modern industry needs a lot of water for manufacturing products; the wastewater after treatment will be used in three ways (Abdelmagid, 1999) as drinking water for irrigation of any kinds of trees that can be used for food human beings and animals. The discharge of effluents rich in sulphate and nitrate is of increasing concern (Esadeg, 1985). Discharging industrial effluents containing high sulphate concentrations into surface waters contributes directly to mineralization and corrosion potential of the receiving waters, while nitrate contributes to eutrophication and is toxic to infants and toddlers (Esadeg, 1990). Sulphate originates from the use of sulphuric acid in manufacturing, chemical and metallurgical processes (Poland, 1992) or from the oxidation of pyretic material in our bodies under natural conditions. Nitrate originates from domestic wastewater, or from fertilizer and explosive manufacturing. Unacceptably high concentrations of sulphate and nitrate may occur in cooling water due to evaporation. Sulphate and nitrate can be removed from water by desalination processes (Middleton and Lawrence, 1999) such as reverse osmosis and ion exchange, but these are costly. Hence increasing attention has been given to biological sulphate removal (Maree and Hill, 1989) and biological nitrate removal (Metcalf and Eddy, 2013). Sulphate can be removed biologically provided that a suitable energy source is available, e.g. Lactic acid (Poland, 2003) wood dust and sewage sludge. Good sulphate removal was obtained for all the carbon sources (Hammer, 1986) but a long retention time of 5-10 days was required for the latter two. Current studies reported that *Moringa oleifera* seed is effective sorbents for removal of heavy metals and volatile organic compounds in the aqueous system (Akhtar *et al*., 2006). Many studies have also been done on the performance of *Moringa oleifera* seeds as primary coagulants .The seed as a coagulant could be used for wastewater treatment (Ghebremichal, 2009). Biological materials such as *Moringa oleifera* have been recognized as cheap substitutes for wastewater treatment and are safe for human health (Fodil and Makkar, 2007). Wastewater treatment station for GIAD factory has already designed since 2018. The problem is ($NaNO_3$ & Na_2SO_4) dissolved in the water after treatment which causes environmental problems.

Objective: the objective of this study is to find a new method of treating the wastewater problem generated from one of the GIAD factory industries by chemical method.

Materials and Methods

Materials

Conical flask of one liter capacity purchased from SFS company, two gas cylinders, H_2 (10 kg), and CO (2 kg) were purchased from liquid AIR company, a stop watch, tuber and bottles (different size), Activated charcoal, Na_2SO_4 conc. (0.8-0.02%V), $NaNO_3$, conc. (1-0.05%v) distilled water were purchased from TANA company. Beakers (100,250,500) ml, digital balance0.01gm, glass rods, spoons and vacuum pump, pH meters AR15_Fisher Scientific2017, filter paper (Whatman), Pipettes Burette, spoon and vacuum pump were purchased from RAHEEG company, we used APHA standard method for the analysis of water and wastewater 20th Edition..

Methods:

The experiments in Omdurman Military Medical Center Laboratories were prepared and carried out, In 1liter of distilled water Na2SO4=5000 mg/L and NaNO3=4000 mg/L, activated charcoal and mixture of gases (CO and H2) were added, under temperature 35oc, which reading in interval 5 minutes this is a test number (1). By the exchanging the concentration Na_2SO_4 = 5500mg/L and $NaNO_3$ = 4500 mg/L, time 2 minutes was chosen, the above reading were taken due to shortage of CO gas , this is attest number (2). By the exchanging the concentration Na_2SO_4 = 6000mg/L and $NaNO_3$ = 5000mg/L, time 2 minutes was chosen, the above reading were taken due to shortage of CO gas, this is a test number (3) .Three testes at different times were done. Each test consisted of five results, which were read and tabulated , see tables (1, 2 and 3). NH_3 and NO_3 tests were carried out in the Constructural and Environmental Labs –Center CO .Ltd (Khartoum-Sudan). The other tests (pH, S, SO_4, C.O.D, and B.O.D) were carried out in the Omdurman Military Medical Centers-Laboratories. Three tables contain the testes results were tabulated and three flow charts were plotted from the obtained data. The Sudanese Standards and Metrology Organization (SSMO) (2008) Law were obtained and studied.

Fig (1) Lab scale experiment

Results and Discussion

The obtained results of three testes at different time were shown in tables (1, 2 and 3). Figures (1, 2 and3) were drown.

Test Number (1):

Concentration:

$NaNO_3$= 8000 mg/L → 4000 mg/L

Na_2SO_4= 10000 mg/L → 5000 mg/L

Table. (1): Effect of $NaNO_3$ and Na_2SO_4 in The Treatment process

Time min	pH unit	**SO_4 mg/L**	**S mg/L**	**NH_3 mg/L**	**C.O.D**	**Pressure bar CO**
5	5.58	3646.9	2	37.33	32	100
10	5.84	3522.35	2	41.06	72	80
15	5.90	3450.3	2	50.40	118	60
20	5.91	3400.48	1.92	64.00	128	40
25	5.96	3300.65	2.56	25.00	129	20
30	5.98	3290.44	2.24	32.00	133	10

Removal SO_4=35.8% B.O.D= 180 mg/L

(i) In first test 5 minutes interval was chosen to each reading and temperature was 35°C under atmospheric pressure. The test results showed that there was reduction between the first and the last concentration, as SO_4 decreased from 3646.9 mg/L to 3290 mg/L in time 5 to 30 min, NH_3 increased from 37.33 mg/l to 64 mg/l in time 5 to 20 min, after 20min reduction happened. C.O.D increased from 37.33 mg/l to 133mg/l in time 5 to 30 min. B.O.D increased to 180mg/l in time 30min.

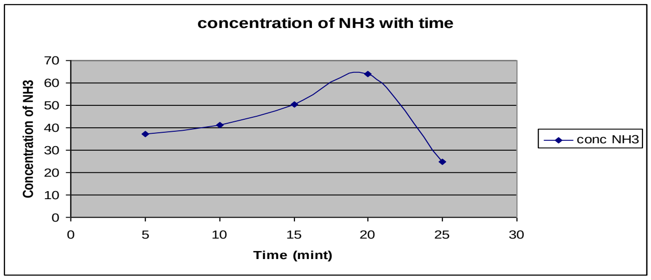

Figure (2): Effect of concentration of $NH_3$with time increase.

Test Number (2):

Concentration:

$NaNO_3$=9000 mg/L → 4500 mg/L

Na_2SO_4=11000 mg/L → 5500 mg/L

Table (2): Effect of $NaNO_3$ and Na_2SO_4 in The Treatment process

Time (Min.)	**pH (unit)**	**SO_4 (mg/L)**	**S (mg/L)**	**NH_3 (mg/L)**	**NO_3 (mg/L)**	**Pressure bar CO**
2	6.35	2518.99	1.8	16.7	278.13	150
4	6.29	2543.68	1.8	18.47	244.53	140
6	6.19	2550.76	1.9	22.60	231.46	130
8	6.18	2333.37	1.8	28.80	209.06	120
10	6.12	2272.03	1.8	29.25	169.866	110
10(x)	6.18	2132.08	8	14.40	110.13	100

Removal: SO_4 =61.3 % NO_3 = 96.3% B.O.D =50 mg/L

(ii) The second test the time of (2) minutes was chosen for every reading because CO gas is not available, temperature was 35°C.The test results showed that there was reduction between the first and the last concentration, as SO4decreased from 2518.99 mg/L to 2132 mg/L in time from 2 to 10 min, NO_3 decreased from 278.13 mg/L to 110 mg/L, in time from 2 to 10 min. The last reading i.e. (10x) was the measurements of the remainder in the flask after the last reading. This reading was taken to confirm the result of the concentration in the last reading .B.O.D decreased to 50 mg/l depending to the time 10 min.

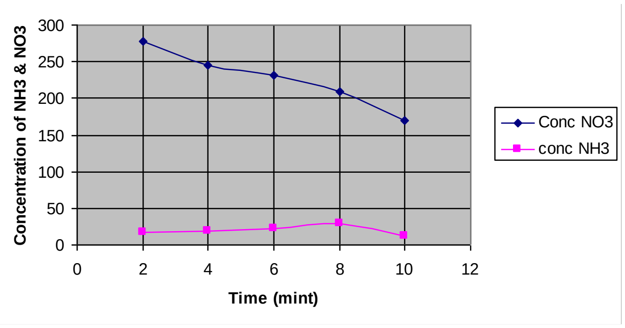

Figure (3): Effect of concentration of NH_3 and NO_3 with time increase

Test Number (3): Concentrations:

$NaNO_3$=10000 mg/L → 5000 mg/L

Na_2SO_4 =12000 mg/L → 6000 mg/L

Table (3): Effect of $NaNO_3$ and Na_2SO_4 in the Treatment process

Time (Min.)	**pH**	**SO_4 mg/L**	**S mg/L**	**NH_3 mg/L**	**NO_3 mg/L**	**pressure bar CO**
2	5.87	2379.04	4	18.5	50.4	110
4	5.74	2296.72	10	20.25	46.66	95
6	5.82	2257.72	14	25.11	29.00	90
8	5.65	2235.45	12	32.00	166.13	80
10	5.79	2169.60	8	12.50	28.86	70
10(x)	5.77	2117.77	10	16.00	14.93	70

Removal SO_4 = 56.4% NO_3 = 99.7 %

(iii) The concentration of NO_3 in 10 minutes was reduction from50.4to 14.93 mg/L which is an ideal value that matches the Sudanese Standards and Metrology Organization (SSMO) Law (2008). The maximum concentration of SO4 in 10 minutes was reduction from 2379.04 mg/l to 2117.77 mg/L. The test results showed that there was reduction between the first and the last concentration, SO4 decreased from 2379.04 mg/L to 2117.77 mg /L, NO_3 decreased from 50.4 mg/L to 14.9 mg/L. The fourth reading the concentration of NO_3 =166 mg/L. This is mostly was due to an experimental or human error .However these odd reading did not affect the general pattern of the results. The last reading i.e. (10x) was the measurements of the remainder in the flask after the last reading. This reading was taken to confirm the results of the concentration in the last reading.

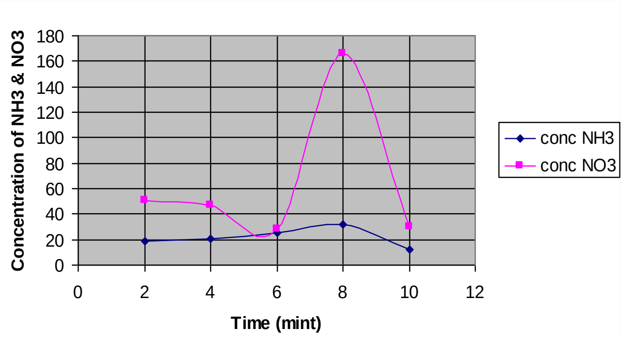

Figure. (4): Effect of concentration of NH3 and NO3 with time increase

A process is described whereby sulphate is reduced to sulfide. Nitrate was converted to ammonia in the anaerobic reactor.

$4H_2+SO_4^{-2} \longrightarrow S^{-2}+4H_2O$………..(1)

$4CO+ SO_4^{-2} \longrightarrow S^{-2}+4CO_2$………(2)

$NO_3+4CO+2H+H_2O \longrightarrow NH_4 +4CO_2$ …….(3)

The suggested flow sheet of the lab scale showed that small scale facilities could be scale up to make a pilot scale. The area of the plant treatment is estimated approximately about 1500 m. Other parameters B.O.D and C.O.D studied in the experiment to be reduced or increased depending to the time of the experiment .From the lab experiments a treatment plant was suggested.

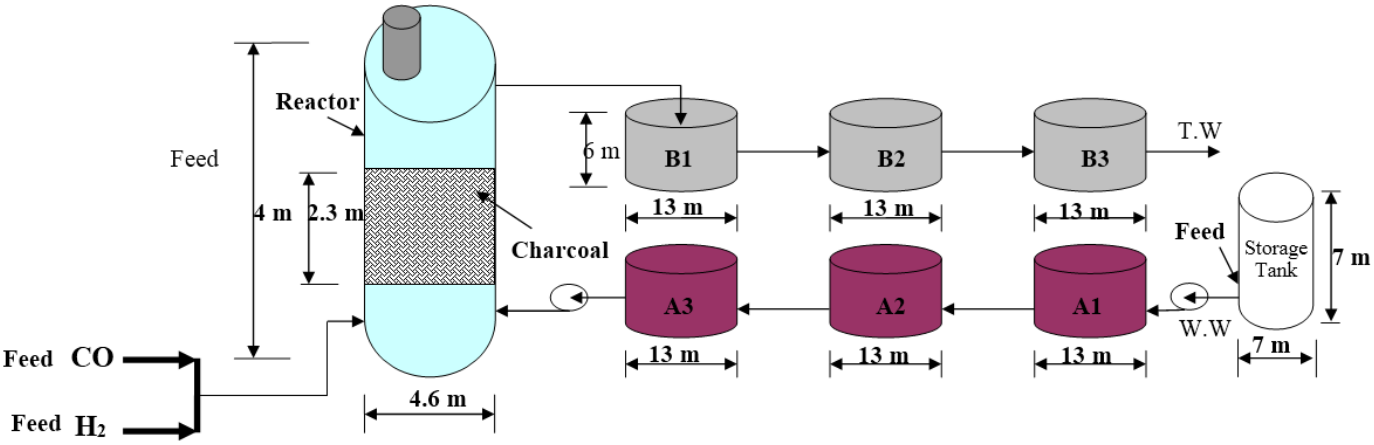

Figure (5) Suggested Flow sheet of Treatment Station A and B represent tank

Conclusion From the results and discussion is concluded, Sulphate is reduced to sulphide under anaerobic conditions with produced gas as substrate. Nitrate was converted to ammonia in the anaerobic reactor. The water after treatment can be used for irrigating trees since the obtained results comply with the value required by Sudanese Standards and Metrology Organization (SSMO) (2008) Law. In this treatment there are no side effects causing pollution to the environment.

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