Bio-Treatment of an Acidic Industrial Wastewater: Tana Explosive Factory

Khalid, H.[1], Yousof A. Yousof[2], Babiker K. Abdalla[1]

[1]Karary University, Chemical Engineering Dept., Sudan
[2]Sudan University of Science and Technology(SUST), Chemical Engineering Dept., Sudan
Khalidco20@gmail.com

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ABSTRACT-Tana is one of the Sudanese Military industries. Manufacturing different types of chemical i.e. (TNT, DNT, and MNT). The pH of the acidic wastewater is 1.7 was mixed together with 10% sodium hydroxide lye and neutralized under agitation in neutralizing tank. After neutralization the pH of water reached the value of 6.In this study anew bio treatment is applied to treat acidic wastewater by using moringa oleifera leaves after grinding and mixing in a tank the result indicated that significant increase in pH from1.7 to5.8 in 3 hours, and with 10%added sodium hydroxide (NaOH) pH value reached 6 that without salt sedimentation and low cost of treatment. The Moringa Oleifera leaves showed good treatment properties especially when used for acidic wastewater of pH value (1.7). Moringa Oleifera leaves can raise pH value to (5.8) in three hours. It is highly recommended that realistic visibility study must be carried out to design and apply the manufacture of the tablets of Moringa.

Keywords: *Biotreatment*, *Moringa* Oleifera, *Acidic wastewater*, *Economic Evaluation*.

المستخلص: يعتبر مصنع تانا احد مصانع التصنيع الحربي في السودان ويقوم بتصنيع أنواع مختلفة من الكيماويات مثل (MNT and MNT TNT,) وينتج من ذلك مياه حمضيه ملوثه تركيز الأس الهيدروجيني فيها 1.7, ويتم معالجتها كيميائيا بخلطها مع هيدروكسيد الصوديوم بتركيز 10%كغسول ويتم خلط المكونات في خزان التعادل وبعد اكتمال المعادلة كان تركيز أس الهيدروجين 6, في هذه الدراسة تم تطبيق طريقه حيوية جديدة لمعالجه المياه الحمضية الملوثة وذلك باستخدام أوراق نبات المورينقا بعد سحنها ويتم خلطها مع المياه الملوثة الحمضية في خزان التعادل وبعد مرور ثلاثة ساعات أظهرت النتائج ألمتحصله زيادة ملحوظة في قيمه الأس الهيدروجيني من 1.7الي 5.8 مع استخدام قليل من 10%هيدروكسيد الصوديوم كغسول وبعد مزيد من الوقت بلغ التركيز6 دون أن يخلف ترسبات ملحيه بجانب ألكلفه ألاقتصاديه القليلة,أظهرت أوراق نبات المورينقا خصائص معالجه جيده خاصة عند استخدامها لمعالجه المياه الحمضية الملوثة ذات الأس الهيدروجيني 1.7 واثبتت أن لها ألقدره علي رفع قيمه الأس الهيدروجيني إلي 5.8 خلال ثلاثة ساعات,نوصي بشده أن يتم عمل دراسة حقيقية لتصميم وتطبيق صناعه المورينقا في شكل حبوب.

1. Introduction

About 20 years ago Biological Nutrient Removals (BNR) for the removal of nitrogen and phosphorus was viewed as an innovative process for advanced wastewater treatment. Because of the extensive research [1] into the mechanisms of BNR the advantage of its use and the number of BNR systems that have been placed into operation nutrient removal for all practical purposes has become a part of conventional wastewater treatment.

When compared to chemical treatment methods BNR uses less chemical reduces the production of waste solids and has lower energy consumption. Because of the importance of BNR in wastewater treatment BNR is integrated into the discussion of theory, application, and design of biological treatment systems. Land treatment processes commonly termed natural systems, combine physical, chemical, and biological treatment mechanisms [2] and produce water with quality similar to or better than that from advanced wastewater treatment.

Natural systems are not covered in this text as they are used mainly with small treatment systems. Earlier research findings of [3] showed that the chemicals used for water purification can cause serious health hazards if an error occurs in their administration during the treatment process. These reports suggested that a high level of aluminum in the brain is a risk factor for Alzheimer's disease.

Also studies by workers [4] have raised doubts about the advisability of introducing aluminum into the environment by the continuous use of aluminum sulphate as a coagulant in water treatment. Moringa Plant is a native of parts of Africa and Asia. It is the sole genus in the flowering plant family Moringaceae. It contains 13 species from tropical and subtropical climates that range in size from tiny herbs to massive trees.

Moringa species grow quickly in many types of environments and can be used for wastewater treatment, food to humans and farm animals and for the production of biodiesel. Moringa oleifera Lam is a perennial plant that grows very fast, with flowers and fruits appearing within 12 months of planting. They grow up to a height of 5-12 meters and pods 30-120 cm long [5-6] and are harvested up to two times a year in India.

The tree prefers lowlands in hot semiarid conditions with sandy or loamy soils [7] but is known to adapt to new conditions quickly. It tolerates light frost, a soil pH of 9 and can live in areas with annual rainfall of up to 3000 mm. Today it can be found on elevations up to 2000m in Zimbabwe [8].

Seeds of plant species like Moringa oleifera contain natural polyelectrolyte's which can be used as coagulants to clarify turbid waters. In laboratory tests, direct filtration of turbid surface water, and fecal coli forms used to be treated with seeds of Moringa olifera coagulants, producing a substantial improvement in its aesthetic and microbiological quality. These methods appear as suitable for home water treatment in rural areas of developing countries.

These natural coagulants produce 'low risk' water; however, additional disinfection or boiling should be practiced during localized outbreaks/epidemics of prevalent infections. A natural coagulant from animal origin is also an effective coagulant [10].. It has unique properties among biopolymers, especially due to the presence of primary amino groups. It is a high molecular weight polyelectrolyte derived from deactivated chitin and it has characteristics of both coagulants and flocculants: high cationic charge density, long polymer chains, bridging of aggregates, and precipitation (in neutral or alkaline pH conditions).

It has also been used for the chelating of metal ions in near-neutral solution and the complication of anions in acidic solution (cationic properties due to amine protonation). Its coagulation and flocculation properties can be used to treat particulate suspensions (organic or inorganic) and also to treat dissolved organic materials. It has also been reported that chitosan possesses antimicrobial properties [11]. By using natural coagulants, considerable savings in chemicals and sludge handling cost may be achieved. [11] Reported that 50 – 90% of alum requirement could be saved when okra was used as a primary coagulant or coagulant aid. Apart from being less expensive, natural coagulants produce readily biodegradable and less voluminous sludge.

For example, sludge produced from M. Oleifera coagulated turbid water is only 20 – 30% of that of alum treated water [10- 11]. The coagulation process in water treatment is complimented by filtration. The successfulness of coagulation in most cases determines the performance of the filtration system, which may be of a mono medium or dual media type.

The mechanism of coagulation was suggested to be adsorption and neutralization of charges, or adsorption and bridging of destabilized particles, the two assumed to take place simultaneously[12-13] reported the isolation from M. Oleifera of a flocculating protein of 60.Residues with molecular mass of about 6.5 kDa, is electronic point above pH 10, high levels of glutamine, arginine and proline with the amino terminus blocked by pyroglutamate, and flocculent capacity comparable to a synthetic polyacrylamide cationic polymer. However, a non-protein coagulant has also been reported but not characterized [11].

The knowledge that seeds from the Moringa Oleifera tree can purify water is not new; the seeds have been used for generations in countries like India and Sudan. Women of Sudan have used the technique of swirling seeds in cloth bags with water for a few minutes and letting it settle for an hour. This procedure is today recommended by different agencies (PACE and ECHO etc.) for people with limited access to clean water.

The required area for cultivation of Moringa when used for drinking water treatment is dependent on the raw water and dosage. With a production of 3 kg seed kernels per tree and year and a dosage of 100mg/l, 30 000 liters of water can be treated from one tree. By assuming tree spacing of 3 m, an area of 1 ha can treat 30000m annually [14].

In recent times, there has been an increasing trend to find some indigenous cheaper material for wastewater treatment. Since the conventional procedure of wastewater treatment has some disadvantages, such as incomplete metal removal, high cost and high energy requirements, biological materials have been recognized as cheap substitutes for wastewater treatment.

Current studies report that Moringa seeds and pods are effective sorbents for removal of heavy metal and volatile organic compounds in the aqueous system [4].

It can be added in oxidation lagoons of wastewater treatment units to coagulate algae as well.The algae are removed by sedimentation, dried and pulverized, and then used as protein supplement for livestock [14]. The unique characteristic of Moringa seeds could be a possible solution for the developing countries which are suffering from lack of clean water for irrigation.

Tana is one of the Sudanese Military Factory manufacturing Tri-nitro-toluene (TNT), Di-nitro-toluene (DNT) and Mono-nitro-toluene (MNT). The designed capacity of the factory acidic wastewater production is 288 m^3/day; with a treatment ability of 12 m^3/hour. According to the data from the process design, concentration of the nitro compounds in acidic wastewater is less than 210 mg/l. While the concentration of acid as H_2SO_4 is less than 1% and the Nitro compounds are less than 5mg/l, with a pH value between 6 to 9.

The wastewater treatment building covers an area of about 432 m^2. The classical treatment consisted of; acidic wastewater is mixed with 10% sodium hydroxide lye and neutralized under agitation in the neutralizing tank, it took two and half hours and consumption 1.5 ton/day, one-ton cost about 10000$. The pH value of wastewater after neutralization is round 6. Depending on the previous studies a treatment by natural plants are not lucky because they did not find sufficient care of research, especially military manufactures liquid wastes. So, the study of Moringa leaves as its properties in the treatment of acidic military liquid wastes.

The objective of this research is to find a new method of treating an acidic wastewater by Moringa leaves because Moringa leaves contain proteins and water-soluble proteins that act as effective for water and wastewater treatment, with low cost as well as zero-environment bad or negative effect.

2. Material and Methods

In several experiments the acidic wastewater used to be collected from Tana factory. Samples used to be collected in glass container and the characterization of acidic wastewater samples were conducted immediately after the sample arrived to laboratories. Care was taken not to introduce errors during sampling and storage, where contamination results from improperly cleaned sampling devices and sample containers. A diagram of lab scale that consists of beakers, digital balance, glass rods, spoons, pH meters, paper filter, burette, spoon and vacuum pump, as well as Two Liters of acidic wastewater from Tana factory with pH 1.7 have been purchased. On the other hand two bottles (500 mg) of dried and ground Moringa have been prepared. The experiments has been carried out in Karary University chemistry laboratories, amounts of 2.5gm, 5.0gm, 7.5gm, and 10.0 gm of Moringa leaves have been added to conical flasks and then filled with a 100 ml of acidic wastewater, corresponding equal to 97.5, 95, 92.5 and 90 ml.Four testes, at different times, have been carried out at 35 degree Celsius.

Each test gave four results which have been read and tabulated in Tables 1. Four tables of which have been further tabulated and three flow charts have been plotted from the already obtained data. Recycle leaves have been dried and used two times as well as pH has been measured.100 ml of 10% sodium hydroxide have been prepared. The flow sheet of the lab scale showed that; small scale facilities could be scaled up to make a pilot plant.

3. Results and Discussions

pH meter is used and acidic wastewater of pH value 1.7 mixed with Moringa leaves in different weight and time, four tests were carried out each test consist of four results, which were read and tabulated. Flow charts were plotted from the obtained data. Tables 1 and 2 were obtained. Figure 1 was drowning.

TABLE 1: EFFECT OF MORINGA LEAVES IN THE TREATMENT PROCESS.

Weight gm	PH/1hr	PH/2hr	PH/3hr	PH/4hr
2.5	3.83	3.93	4.05	3.46
5	4.27	4.34	4.59	4.15
7.5	4.47	4.86	5.19	4.41
10	4.61	5.04	5.76	4.53

At first 1 hr was chosen for any reading, temperature 35degree Celsius under atmospheric pressure. Four readings were obtained for different weights. The test result showed that there was an increase from (1hr—3hr) in pH value until it reached 5.76. Within 4 hr there was reduction in pH values. So that 3 hr is a suitable time to obtain a high value of pH in different weights.

TABLE 2: EFFECT OF RECYCLED MORINGA LEAVES IN THE TREATMENT PROCESS (USED TWO TIMES).

Weight gm	pH/3hr
7.5	5.13
7.5	5.03

(a) Recycle Moringa leaves Used two times

The researchers has chosen 7.5gm for the first time, the result was a maximum saturation point, then the researcher dried the filtered Moringa leaves and used them for the second time, the result was 5.13pH/3hr.Then the Moringa leaves have been dried and used for the third time the result was 5.03pH/3hr. Finally, the researchers concluded that Moringa leaves could be used three times to treat the acidic wastewater effectively.

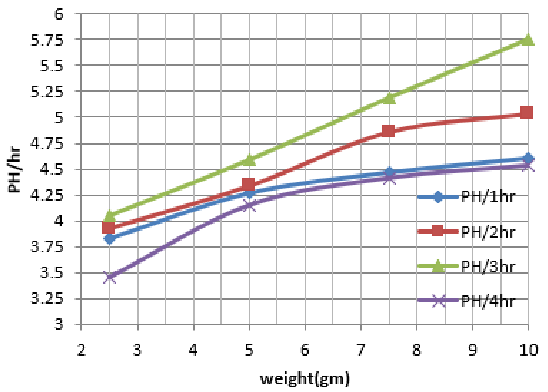

Figure 1: variation of pH value with Moringa weight

(b) For the existing treatment method

Acidic wastewater about 288m^3 /day of pH value 1.7 were mixed with 10% sodium hydroxide and pH value reached (6-9) it took two and half hours. Salt settled in tank of treatment. High cost of treatment using sodium hydroxide, the material is very expensive because it is rare in Sudan, consumption of NaOH 1.5ton/day about 450ton/year, year about 300day, the cost of one ton about 10000$. Nowadays NaOH is widely used in an acidic wastewater treatment plants all over the world.

(c) Suggested environmental treatment using (Moringa leaves)

Moringa trees are planted around the factory; tests have been conducted using these Moringa Trees. A wastewater of acidic pH value 1.7 mixed with dry leaves of Moringa and within three hours' time pH value became 5.76. Using 10% sodium hydroxide until pH value becomes 6. No salt settled in tank of treatment. The recycling of leaves which have been used for two times gave pH value (5.13&5.03) for Moringa. The wastewater after treatment has been used for irrigation of trees of Moringa around the factory; the recycled leaves have been used as isolation. Finally, Moringa seeds have been used as a coagulant in drinking water treatment systems.

The Moringa Oleifera leaves showed good treatment properties especially when used for acidic wastewater of pH value (1.7). Moringa Oleifera leaves can raise pH value to (5.8) in three hours. Moringa olifera leaves acts as a natural alkaline for the treatment of acidic wastewater, the results obtained evidenced that Moringa Olifera leaves is found to be a sustainable, cheap solution for acidic wastewater treatment. Also the Moringa Oleifera leaves can be produced locally at low cost.

There for the use of Moringa Oleifera (leaves and seeds) should have several technical benefits, especially in tropical developing countries and rural communities; there is no side effect to the environment.

4. Calculations

A: Before treatment, acidic wastewater pH value =1.7, volume of Na0H = 200ml, concentration of sodium hydroxide =0.1, molecular weight of NaOH = 40. According to Table 3 which show pH values of acidic wastewater before adding Moringa, the researcher has used the classical treatment method in which sodium hydroxide (NaOH), it is found that 24ml of (NaOH)is needed so that the value of pH will reach between (6-9) which is high cost, $W_{NaOH}=(m \times v \times wt) \div 1000$ (1) $= 0.096gm$, see Figure 2.

TABLE 3: SHOWS PH VALUES OF WASTEWATER BEFORE ADDING MORINGA.

V (ml)	pH	(ml)	pH
2	2,76	16	3.54
4	2.82	18	3.78
6	2.89	20	4.o9
8	2.96	22	5.02
10	3.06	24	6.86
12	3.18	26	9.05
14	3.34	28	9.83

B: Moringa

After treatment time of three hours, volume after separation treated water from leaves by filter paper=73ml, pH=5.76, mt = 40, concentration of sodium hydroxide=0.1, volume of NaOH = 100ml.

According to table (4)which shows pH of wastewater after treatment by Moringa.The researcher has used the suitable suggested environmental treatment using Moringa leaves.it is found that with 3ml of (NaOH)the pH value reached (6-9)which low cost, $W_{NaOH}=(m \times v \times wt) \div 1000\ (2)\ = 0.012gm.$ To compared with 200ml in (A) =0.0328 gm, see Figure 3.

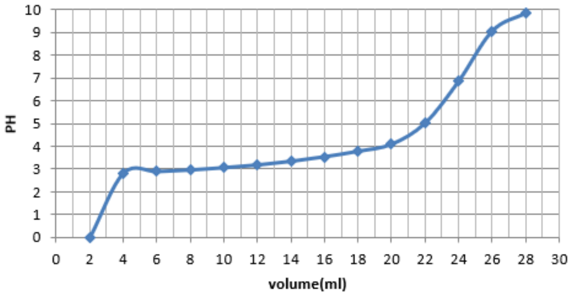

Figure 2: Variation of pH of wastewater with volume of NaOH

TABLE 4: PH VALUES OF WASTEWATER AFTER TREATMENT BY MORINGA

V ml	pH	V ml	pH
1	5.83	11	7.58
2	5.96	12	7.73
3	6.12	13	7.85
4	6.31	14	7.97
5	6.49	15	8.08
6	6.69	16	8.20
7	6.87	17	8.33
8	7.06	18	8.44
9	7.26	19	8.54
10	7.41	20	8.63

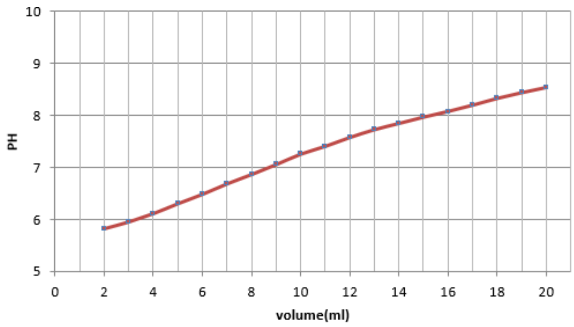

Figure 3: Variation of pH of wastewater with volume of NaOH

5. Economical Evaluation

The researcher made comparison of the cost between classical treatment method and new Bio treatment method by moringa leaves beside recycle leaves, table (5and6) illustrated that. By Using equation (LnpH).

(a) Cost estimation for classical method and moringa leaves,table (5)showed that

TABLE 5: PH VALUES OF MORINGA.

pH	Ln pH
1.7	0.183
5.8	0.003
6	0.0025

(i) Total cost without moringa =4500000$/year.

(ii) Total cost with moringa =12500$/year.

(b) Cost estimation for recycle leaves, Table 6 showed that:

TABLE 6: PH VALUES OF RECYCLE MORINGA.

pH	Ln pH
5.13	0.0059
5.03	0.0065

Total cost with recycle moringa=85000$/year.

6. Conclusions and Recommendations

The acidic wastewater with pH 1.7 mixed with moringa olifera leaves pH value reached 5.8 addition a few percent of 10% NaOH until pH value reach 6 it most clears at time three hours. Thus it can be concluded that leaves powder of Moringa Olifera is a reliable natural alkaline, it is eco-friendly and proves to be the cheapest method of an acidic wastewater. The results obtained evidenced that the leaves of Moringa Olifera is a great alternative for use as an acidic wastewater treatment system. The results obtained evidenced that Moringa Olifera leaves is found to be a sustainable, cheap solution for acidic wastewater treatment. of Moringa. It is recommended to do further studies and experimental work for longer period. Since the moringa grows in different sites in the country it is recommended to study tree grown in different place i.e. South Kordofanian, Blue Nile. However, this experiment was only performed for a short period, and further studies need to be carried out to draw definite conclusions on this project.

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