International Journal of Engineering Technology and Scientific Innovation

ISSN: 2456-1851

Volume:02, Issue:01

USING NATURAL COAGULANT TO REMOVE TURBIDITY AND HEAVY METAL FROM SURFACE WATER TREATMENT PLANT IN IRAQ

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ABSTRACT

The use of alum dose in drinking water treatment plant has harmful effects on human health, on the one hand and on the other hand, a process that alum coagulant dose used in drinking water treatment plant with a high processing cost. In this study, the use of Aleskan Compact Drinking Water Treatment Plant in Ad Diwaniyah city in Iraq for the purpose of conducting experiments adding Moringa Oleifera seed and leaves (as a natural coagulant) instead of alum dose to treat drinking water to remove turbidity and heavy metals from surface water. The study samples were taken from the Ad Diwaniyah River, as well as water samples were taken from the all basins of Aleskan Compact Drinking Water Treatment Plant in Ad Diwaniyah city. Experimental runs were carried out for three hours per run over an eight month period with turbidities ranging from 20 to 1000 NTU. Proven results of the study that by using natural coagulant Moringa oleifera seed and leaves (which is a natural trees available in the province of Ad Diwaniyah In Iraq) instead of alum does not carry any impact on human health , and has a high efficiency up to 99% in the removal of turbidity from surface water and up to 98% in the removal of heavy metals from surface water. The turbidities and heavy metal during most of the test runs satisfied the WHO for Potable Water Supplies.

Keywords: Moringa Oleifera, Turbidity, Heavy Metal, Water Treatment Plant, Surface Water

INTRODUCTION

The usage of alum-based coagulant in drinking water treatment process caused residues in treatment completed drinking water, which are eventually supplied to consumers. This poses possible risk to their health. Furthermore, alum-based coagulant is expensive. Due to the risk and cost of using alum-based coagulant, natural coagulants which are environmental friendly, safe and cost effective, are needed

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ISSN: 2456-1851

Volume:02, Issue:01

[1]. Therefore, it is necessary to search for other cost effective and more environmentally acceptable alternative coagulants from natural resources to present a viable alternative for water treatment processes [2].

Many researchers have used *M. Oleifera* ***(*MO*)*** seed and other plants as natural coagulants for water treatment [3, .4, 5, 6, 7]. *Moringa oleifera* (family *Moringaceae*) is a tropical plant known to contain coagulating/flocculating and a biosorbent compounds in the seeds and leaves (Figs. 1 and 2).

Figure 1: Moringa Oleifera seeds and leaves

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ISSN: 2456-1851

Volume:02, Issue:01

Figure 2: Moringa Oleifera seeds

New uses of **MO** seeds and leaves have been found by many researchers for the last two decades which introduced new material in water treatment industry. In addition, it was found that it can work as a biosorbent for heavy metals in water treatment. Therefore, it can be considered as a natural product and environmentally friendly material [8]. In addition the possibility of using **MO** leaves in water treatment industry. It was found that **MO** leaves extract is a good sorbent for Pb(II) from aqueous solutions [8]. Chemically Modified Moringa oleifera leaves powder was used by [9] for optimization of Cd(II), Cu(II) and Ni(II) biosorption. Removing of Cd(II) from waste water was achieved using fresh leaves as biosorbent [7] .

This study was intended to use of Aleskan Compact Drinking Water Treatment Plant in ADiwaniyah city in Iraq intended to explore the effectiveness and optimum dosages of **MO** needed for turbidity and heavy metals removal instead of alum dose in surface water sources. Two types of heavy metals (lead, and aluminum) and three level of turbidity were chosen for this study (high turbidity 500-1000 NTU, medium turbidity 50-250 NTU and low turbidity 20-50 NTU). The experiment was performed with crude extracts of **MO**, with different dosage (25 %

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ISSN: 2456-1851

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w/w oil was extracted from the seed kernel, 32.0 mg/L and 50 mg/L to 80 mg/L).

Figure 3: Location of Aleskan Compact Drinking Water Treatment Plant

Water Sample

Aleskan Compact Drinking Water Treatment Plant (ACDWTP) in south of Ad Diwaniyah city is a conventional surface drinking-water system that obtains its main raw water supply from Ad Diwaniyah River in city (fig. 3).

The raw water pumping station is located on the shore and supplies the treatment plant via a 30 m pipeline. Aleskan Compact Drinking Water Treatment Plant has a rated capacity of 200 m3/hr. The 2014 and 2014 treated water flow records indicate that the plant is operating at average daily flows of approximately 70 percent of the plant's rated capacity. A schematic of ACDWTP is shown in fig. 4.

Aluminum sulphate coagulant is added to the incoming raw water before it is directed to a flash mixer. After the flash mixer, the flow is split and conveyed to twin flocculation/sedimentation chambers that operate in parallel. Each flocculation chamber consists of six (6) cells, and the sedimentation basins are equipped without tube settlers. The water is filtered through five (5) pressure filters. The filter effluent is directed to an underground clearwell where it is chlorinated. The study samples were taken from the ADiwaniyah River near Ad Diwaniyah Tires Factory, as well as water

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ISSN: 2456-1851

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samples were taken from the all basins of Aleskan Compact Drinking Water Treatment Plant in Ad Diwaniyah city. The raw water quality parameters measured during the experimental runs were; pH 6.3 to 7.5; Alkalinity 0.89 to 2.98 mg/L as CaCO3.

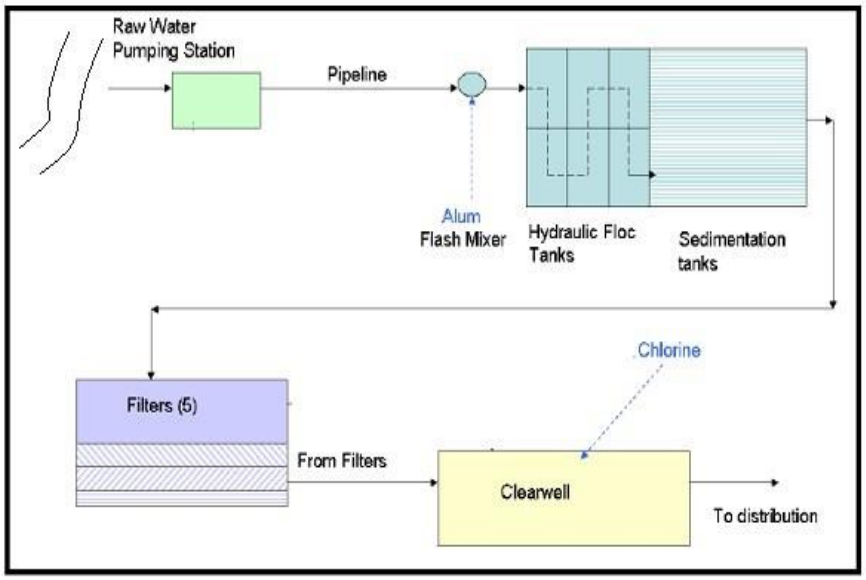

Figure 4: Aleskan Compact Drinking Water Treatment Plant

MATERIALS AND METHODS

Preparation of M. Oleifera Seed and Leaves Suspension

The Preparation procedure of **MO** Seed and Leaves Suspension in this study depends on the studied results by Muyibi et al [9]. Dry **MO** seeds used in the study were obtained from trees in Diwaniyah city In Iraq . The seed wings and coat were removed and the seed kernel dried in the oven at 50 oC for 24 hours. The seeds were ground using a domestic food blender. Oil was extracted from the ground seed using a Soxhlet apparatus and

hexane as the solvent. Only 25 % w/w oil was extracted from the seed kernel because in a previous related study, it was observed that extraction of 25 % w/w oil from **MO** seed powder gave the best performance when applied to coagulation of turbid water [10]. Five grams of oil extracted seeds (remaining cake) powder was blended at high speed for two minutes in a variable speed domestic food processor with 200 ml of distilled water added. The resulting

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ISSN: 2456-1851

Volume:02, Issue:01

suspension was filtered through a clean muslin cloth in a beaker and the filtrate made up to a final volume of 500 ml to yield a stock solution of approximately 10000 mg/L.

Experimental Methods

A Jar test apparatus in fig. 5 was used to obtain the optimum **MO** coagulant dose for each experimental run. A portable Turbidity Meter in fig.6 was used to measure the turbidity. The pH of samples was measured using Bench pH meter. A four paddle standard jar test with variable rotational speed and four 1000 mm jars was used. Each jar was added with 300mL water sample and then different concentrations of **MO**; 0.0mL, 32.0mL, 50.0mL and 80.0mL were added. The standard procedure implies 3 minutes of rapid mixing (200 rpm) in the incubator shaker at 21oC temperature followed by 30 minutes of slow mixing (50 rpm) for flocculation.

Figure 5: Jar Test

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ISSN: 2456-1851

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Figure 6: Turbidity Meter

A sample of raw water was collected from the river and jar tests carried out to determine the effective dose for each experimental run. Test runs were carried out for three hours per run over an eight month period. The stock solution of MO required for the 3-hour experimental run was prepared according to the effective dose obtained from the jar tests. During each run water samples were taken every 30 minutes from the river, settling tank and from the treated water. Turbidity, pH, and heavy metal were measured for both raw water and treated water from the filter outlet [11].

The treated water was allowed to settle for 20 minutes and 100 ml of the sample was taken from the top of each jar to be measured and analyzed for turbidity, Pb, and Al. Jar test was conducted by adding different dosage of concoction of the two crude plant extract to the 250ml of prepared water samples. The test was done to determine optimum dosage and proportion needed to prepare the efficient coagulant in removing Pb, Al, and turbidity. The water sample with certain concentration of heavy metals and turbidity was analyzed before and after jar test. Atomic Absorption Spectrophotometer (AAS) was used to identify the concentration of heavy metals. The difference in concentration of turbidity, Pb, and Al before and after treatment was used to indicate the effectiveness of MO in reducing these parameters in raw water.

RESULTS AND DISCUSSION

4.1 Turbidity Removal

Low Turbidity (10 To 50 NTU)

The results of the dosage optimization of MO using jar test is a dose of 32 mg/L using 25 % w/w oil extracted MO seed, MO reduced the turbidity from 50 to 4.3 NTU, corresponding to a turbidity removal of 91.4%. fig. 7 shows the average results of 3 runs (compact water treatment plant) of

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ISSN: 2456-1851

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9 hours duration when the surface water turbidity was low varying from 20.0 – 50.0 NTU. The residual turbidity varied from 0.5 to 4.3 NTU which was well within the WHO limitation. It is pertinent to note that MO performed very well as a primary natural coagulant in the removal of turbidity from water with low initial turbidity. The pH values revealed that MO did not significantly affect the pH of the treated water, which remained almost constant at 6.4 and 6.5 for all dosages tested. The effective dosage of MO in the ACDWTP operation after flocculation/settling is illustrated in fig. 7. All previous studies in which MO seed extract was used as primary coagulant, no oil was extracted from the seed kernel before application [9].

Moderate Turbidity (From More Than 50 To 250 NTU)

Fig. 8 shows the results of coagulation mechanism study on moderate turbidity water with initial turbidity of 51 NTU to 250 NTU, using **MO** crude extract to test the effectiveness of the coagulant in turbidity removal. The effective dosage of **MO** used was a dose of 32 mg/L using 25 % w/w oil extracted **MO** seed. Based on the results obtained, rapid reduction in turbidity to 3.10 NTU at 32.0 mg/L crude extract with 95.8% reduction, The turbidity dropped from 250 NTU to 5.6 NTU after filtration at the beginning of the experiment and reduced gradually to 4.6 NTU with 97.7% reduction, satisfying the WHO limited.

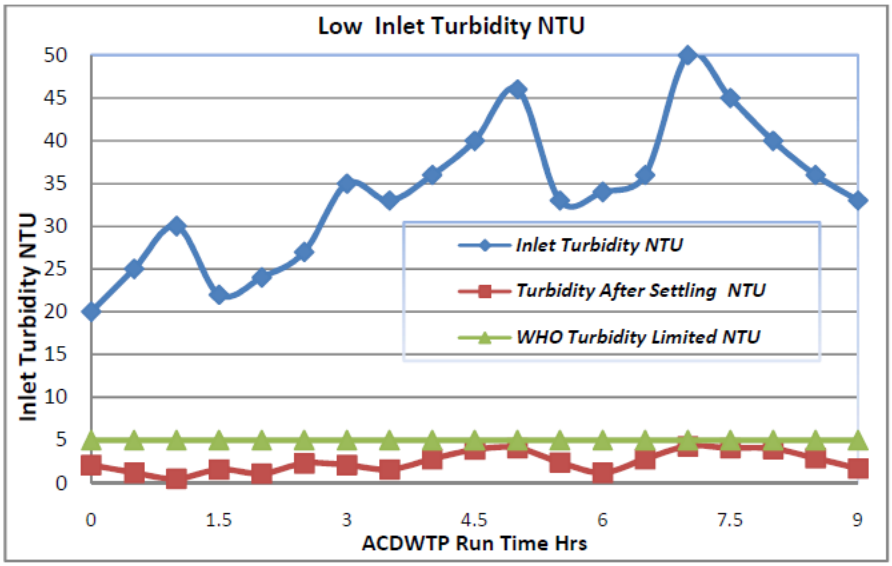

Figure 7: The effective dosage of MO in the ACDWTP operation after Flocculation/Settling tank

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ISSN: 2456-1851

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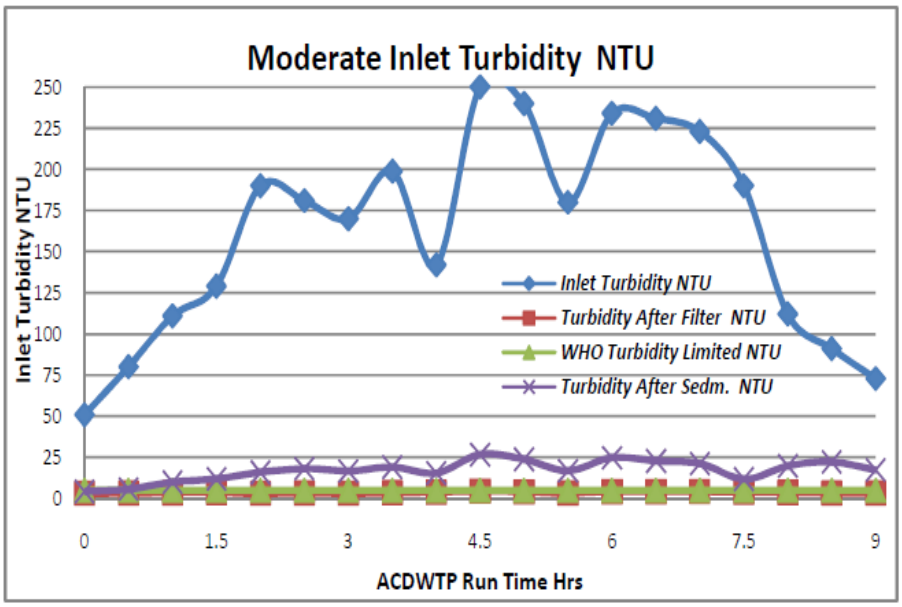

Figure 8: The effective dosage of MO in the ACDWTP operation after Flocculation/Settling and Filter tank

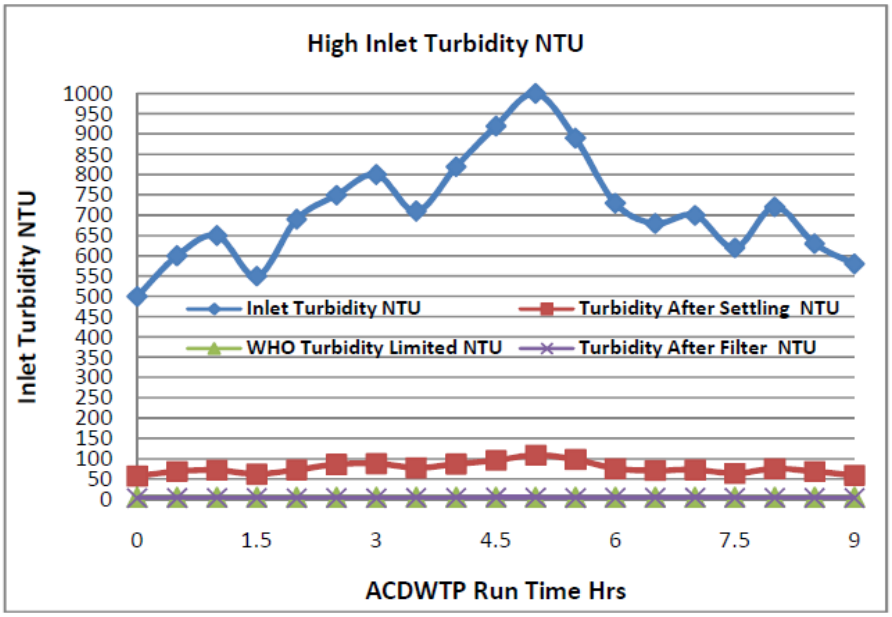

Figure 9: The effective dosage of MO in the ACDWTP operation after Flocculation/Settling and Filter tank

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ISSN: 2456-1851

Volume:02, Issue:01

High Turbidity (From 500 To 1000 NTU)

The effective dosage of **MO** used varied from 50 mg/L to 70 mg/L using 25 % w/w oil extracted **MO** seed as the primary coagulant in the ACDWTP operation is illustrated in fig. 9. Fig. 9 shows the reduction rate of turbidity with initial concentration of 500 to 1000 NTU and after treated with **MO** crude extract, it was seen that, significant reduction of turbidity was recorded with the reduction rate of 88.5% at 50.0 mg/L crude extract in the flocculation/settling tank.

The turbidity concentrations slowly decreased from 50.0 mg/L to 70.0 mg/L crude extract dosage and the maximum reduction rate of 99.8% was recorded at 70.0 mg/L crude extract after filtration. After the sand filtration stage, the percentage of turbidity removal was 99% where the final effluent quality was consistently close to or below 4.9 NTU and thus substantially below the WHO guideline for drinking water of <5 NTU.

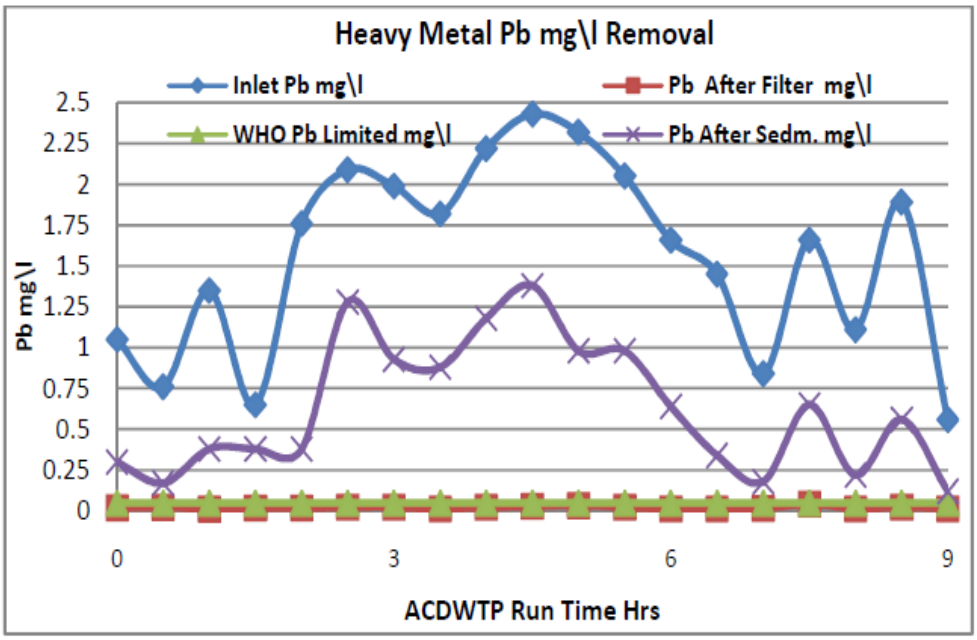

Figure 10: Pb Removal Efficiency through Coagulation process using MO

Heavy Metals Removal

This study focus on the effectiveness of **MO** crude extract used as coagulant in removing the Pb and Al from water samples, which was synthesized in the sanitary laboratory of Collage of Engineering Al-Qadisyiah University.

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ISSN: 2456-1851

Volume:02, Issue:01

Fig.10 shows the Pb removal efficiency through coagulation mechanism using **MO** plants crude extract. It was observed that, the Pb concentration decreased as the dose of coagulant increased and the elimination of lead were stabilized from 32 mg/L to 70.0 mg/L of coagulant applied. The removal rate of iron was 98.0 % after treated with 60.0 mg/L crude extract.

Fig.11 shows the residual of Al after treated with **MO**crude extract. There was a reduction of Al concentrations after treated with **MO** crude extract but the reduction rate was small (75.1%). The effective dosage of **MO**used was a dose of 32 mg/L to 80 mg/L using 25 % w/w oil extracted **MO**leaves.

Based on the test performed for the Pb, and Al contents in crude **MO** extract, Pb recorded the highest content as compared to Al with the concentrations 0.269 mg/L (fig. 11). Hence, the **MO** crude extract is suitable to be used as coagulant in removing Pb in water samples as it has high Pb concentrations in the plant.

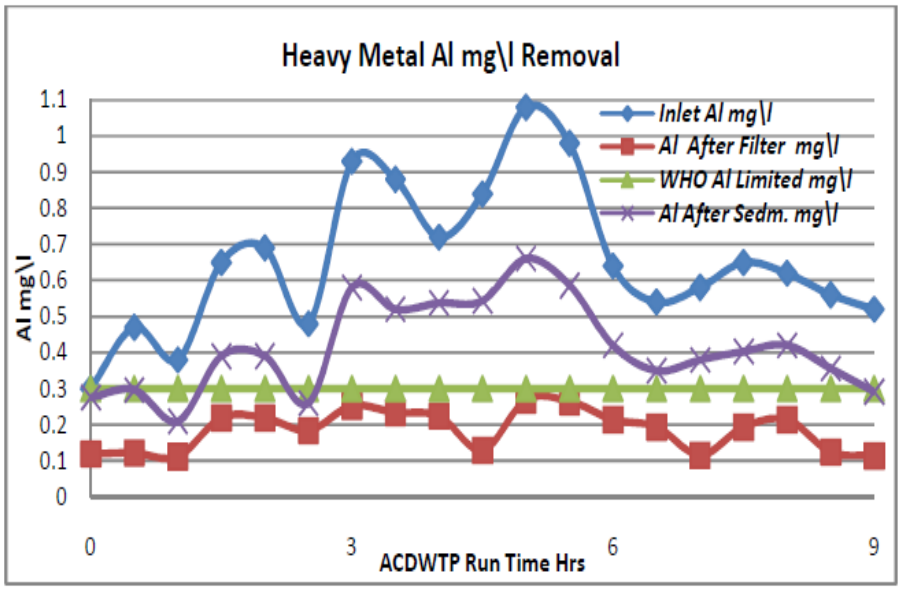

Figure 11: Al Removal Efficiency through Coagulation process using MO

The results shows that, **MO** seed extract can remove turbidity up to 99 % at the dosage of 32 mg/L but the optimum concentrations would be 70 mg/L with the removal rate of 99.8 %. On the other hand, **MO** leaves extract has a very good Pb, and good Al removal capacity with the rate of removal ranged between 98.0% to 75.1%.

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ISSN: 2456-1851

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CONCLUSION

It could be concluded that the application of **MO** in the ACDWTP showed that it can be used effectively as natural coagulant to replace chemical coagulant in removing suspended solids in water, and it is effective in eliminating heavy metals for water treatment. M. oleifera used for the test runs was obtained from the jar test results are 25 % w/w oil , 32 mg/L, and 50 – 80 mg/L for turbidity and heavy metal feed water removed an average 99 % and 98 of the initial turbidity and heavy metal of the raw water. The quality of water treated using **MO** was well below the WHO guideline for drinking water of <5 NTU , <0.05 mg/L Pb, and < 0.3 Al mg/L after filtration.

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