An Investigation of Moringa Oleifera Seed Extract as a Natural Coagulant in Water Treatment

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***Abstract*—This study investigated the suitability of moringa oleifera seed extract as a natural coagulant in water treatment. Highly turbid water was collected from a river in the eFolweni Amanzintoti area, near Durban, South Africa. Collected water samples were dosed with varying concentrations of moringa oleifera seed extract: 50 mg/l, 100 mg/l, 150 mg/l, 200 mg/l and 250 mg/l. The collected water samples from the river were analyzed before and after treatment with moringa oleifera seed extracts at varying concentrations for different parameters – pH, conductivity, turbidity and total solids – to evaluate the suitability and effectiveness of moringa oleifera seed extract in treating highly turbid water. Significant reduction in all parameters analyzed with increased doses of moringa oleifera seed extract was observed, with the exception of the pH, which remained fairly constant at all doses. It was therefore concluded that moringa oleifera seed extract acts as a natural coagulant for the treatment of highly turbid water. This should be an encouragement for developing countries.**

***Index Terms*— moringa oleifera, turbid water, natural coagulants, water treatment, concentrations**

I. Introduction

Water is a vital resource necessary to sustain life. Sustainable freshwater supply and effective treatment are critical needs of many countries. In parts of many developing countries throughout Africa, Asia and Latin America, access to adequate, clean freshwater remains problematic. Lack of access to freshwater supply in many of these developing countries has been the main cause of disease and infant mortality [1]. It was recently documented that 884 million people lack access to good quality drinking water [2]. In South Africa, before the non-racial democratic government took power in April 1994, approximately 15.2 million people lacked access to basic water supply [3]. Substantial progress has been made from 1994 onward as the government has worked to provide access to basic water to all citizens of the country. Even so, the demand for fresh water supply is still significant.

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The use of surface water and groundwater for drinking and domestic purposes in most rural communities within many developing countries has become common practice. This source of water usually requires treatment prior to consumption because this water contains dissolved and suspended solids. The essential removal of these contaminants from this source of water can be carried out through coagulation, a process in water treatment involving the destabilisation of colloidal particles to form flocs that can then be easily removed. This destabilisation is achieved by the addition of positively charged ions known as coagulants to water containing colloidal particles, which are almost always negatively charged. Over previous decades, chemical coagulants have been used in water treatment for the removal of suspended solids and the reduction of the turbidity of water, bacteria and viruses. The common types of these chemical coagulants are aluminium sulphate, ferrous sulphate and ferric sulphate. The application of chemical coagulants in water and wastewater treatments has been determined to cause impurities present in colloidal forms to adhere upon contact, forming flocs which can then be easily removed [4],[5]. However, chemical coagulants are not readily available in developing countries, can be quite expensive for people living in remote rural areas in developing countries, and can pose adverse effects on public health if not applied at the correct dosage. Therefore, the use of natural coagulants of plant origin is a viable alternative to chemical coagulants. It has been widely documented that extracts from plants such as moringa oleifera have proven effective in the removal of suspended solids, in turbidity removal, in the softening of hard water, and also in the reduction of slurry produced as compared with that produced by chemical coagulants [6]-[8].

Moringa oleifera trees grow primarily in tropical and sub-tropical regions around the world[7]. The plant was first cultivated in Northern India and has been used for water treatment in a small scale in this region [8]. It has been widely documented that virtually all parts of the tree are used for one purpose or another: the leaves and pods, highly nutritious, are consumed as vegetables; oil extracted from the seeds contain 40% of vegetable oil by weight; the crushed seeds or the press cakes remaining after oil extraction are used as a natural coagulant in water and wastewater treatment; the press cakes are also used as a soil fertilizing agent; and all parts of the tree have been used in a variety of traditional medicines [9]-[12]. In South Africa, there is a dearth of research pertaining to the importance of moringa oleifera tree. Consequently, this present research was undertaken to demonstrate the suitability of moringa

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oleifera seed extract in treating highly turbid surface water, specifically in a South African context.

II. MATERIALS AND METHODS

In order to investigate the suitability of moringa oleifera seed extract for the treatment of highly turbid surface water collected from the eFolweni River in Amanzintoti along the southern coast of Durban, South Africa, a standard coagulation and flocculation jar test was used. The equipment included an orbital shaker which holds six 500 ml bottles with a regulated speed up to 300 rpm. This equipment is shown in Figure 1.

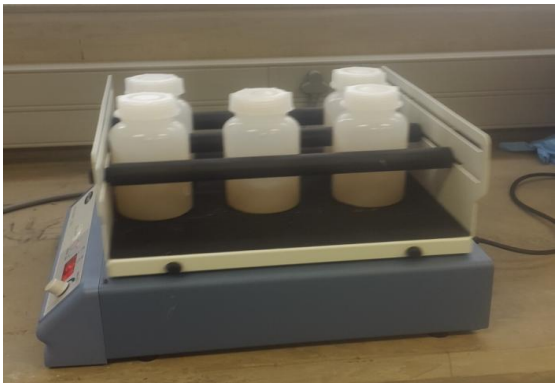

Fig 1: A view of the orbital shaker

The dry moringa oleifera seed obtained from a local commercial supplier was blended into fine particles after the removal of the seed coat. Figure 2 shows the followings: A) the seed prior to the removal of the coat; B) the seed after the removal of the seed coat; and C) the seed when the kernels had been blended into fine particles. The seed powder was weighed and dissolved in distilled water to make stock solution of varying concentrations: 50 mg/l, 100 mg/l, 150 mg/l, 200 mg/l and 250 mg/l respectively. The solutions were then stirred using a magnetic stirrer for 30 minutes and filtered using a filter paper. A fresh stock solution for each of the concentrations was prepared on a daily basis for each run to reduce the effects of ageing on the stock solutions. Five jars were filled with 200 ml each of the highly turbid river water, each jar having water with approximately the same turbidity level. The five jars were then dosed with 10 ml each of 50 mg/l, 100 mg/l, 150 mg/l, 200 mg/l and 250 mg/l of the moringa oleifera seed extract stock solution, respectively, using a pipette. The five jars were then placed on the orbital shaker and mixed thoroughly at a speed of 200 rpm for five minutes to enable total dispersal of coagulant, and 30 rpm for 15 minutes to aid in effective flocculation of colloidal particles.

The bottles were then removed from the shaker and placed on a work bench for an hour to settle the flocs. The supernatant of the treated water was collected and analyzed. Laboratory analysis was conducted both before the commencement of the treatment and after the treatment to analyze pH, conductivity, turbidity and total solids. The above process was repeated for 25 runs with newly prepared moringa oleifera seed extract and freshly collected river water.

Fig 2: A) The seed before the coat was removed; B) the seed after the removal of the seed coat; and C) the seed kernel blended into fine particles.

III. RESULTS AND DISCUSSIONS

The overall aim of this study was to demonstrate the suitability and applicability of moringa oleifera seed extract for the treatment of highly turbid water. The results obtained from the analysis conducted before and after treatment of the turbid water collected from the river with varying dosages of moringa oleifera seed extract are presented in Figures 3 to 6.

Figure 3 presents the results obtained for the pH before and after treatment of the turbid water at varying dosages of the moringa oleifera seed extract. The pH was measured using a calibrated thermo scientific Orion Star A215 pH meter. As can be seen, the pH value of the river water before treatment was 7.5, and the obtained pH value after treatment at varying concentrations of moringa oleifera seed extract ranged between 7.30 and 7.48. Statistical analysis performed using the analysis of covariance (ANCOVA) to determine if significant differences exist between the measured pH of the river water before treatment and after treatment with varying dosages of moringa oleifera seed extract indicated that there were no significant statistical differences ($p>0.05$). This indicates that the use of moringa oleifera seed extract as a coagulating agent for water treatment does not have a significant effect on the pH level, as compared to chemical coagulants that do have a tendency to alter the pH level of treated water to either more acidic or more alkaline in nature.

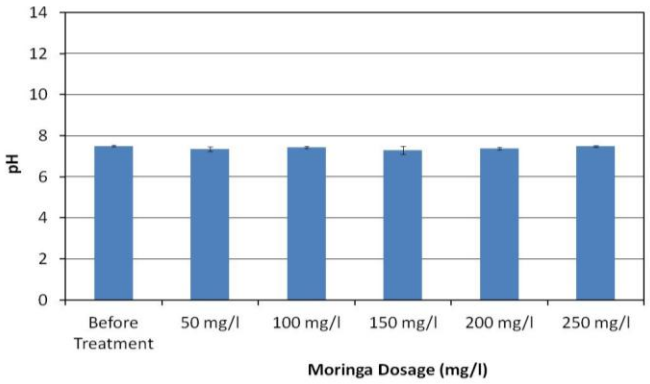

Fig 3: Results obtained for the pH analysis conducted on collected river water before and after treatment using moringa oleifera seed extract at varying dosages.

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The conductivity measurement was performed with a calibrated thermo scientific Orion Star A215 conductivity meter. The same sample used to determine the pH was used for the conductivity measurements. It was also observed from the statistical analysis conducted using the analysis of covariance (ANCOVA) to determine if significant differences exist between the measured conductivity of the river water before treatment and after treatment at varying dosages of moringa oleifera seed extract that there were no significant statistical differences ($p>0.05$) (Figure 4). The conductivity of the river water before treatment was measured at 335.6 µS/cm and remained fairly constant after treatment with varying concentrations of moringa oleifera seed extract.

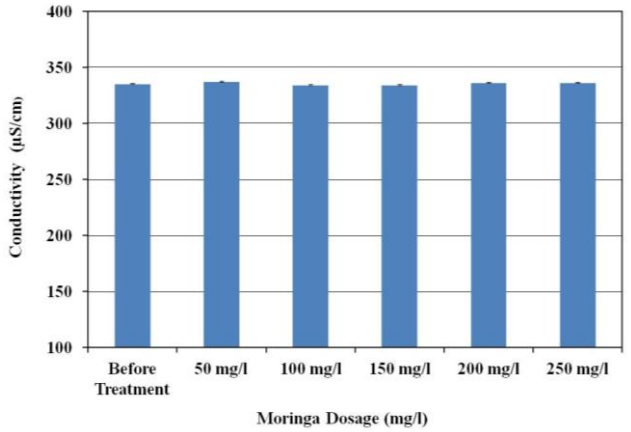

Fig 4: Results obtained for the conductivity measurements conducted on the collected river water before and after treatment using moringa oleifera seed extract at varying dosages

The turbidity results are presented in Figure 5 below. The turbidity measurement conducted before and after treating the collected river water was with turbidity meter TB300 IR Orbeco Hellige. As shown in Figure 5, it was observed that the turbidity of the river water reduced after treatment with increasing dosages of moringa seed extract. The initial turbidity of the collected river water before treatment was measured at 33.8 NTU, and after treatment the measured turbidity at increasing dosages of moringa oleifera seed extract ranged between 23.5 NTU and 3.25 NTU. Statistical analysis conducted using analysis of covariance (ANCOVA) to determine if significant differences exist between the measured turbidity of the river water before treatment and after treatment revealed that there were significant differences ($p<0.05$) for each of moringa oleifera seed extract dosage; however, it was observed that the difference between the effect of the moringa dosages at 200 mg/l and 250 mg/l on the turbidity of the river water before treatment was not statistically significant ($p>0.05$). The overall reduction of the turbidity of the collected river water after treatment with moringa oleifera seed extract was approximately 90%. This observation has also been noted in previous studies: moringa oleifera seed extract has the ability to reduce the turbidity of highly turbid water [13].

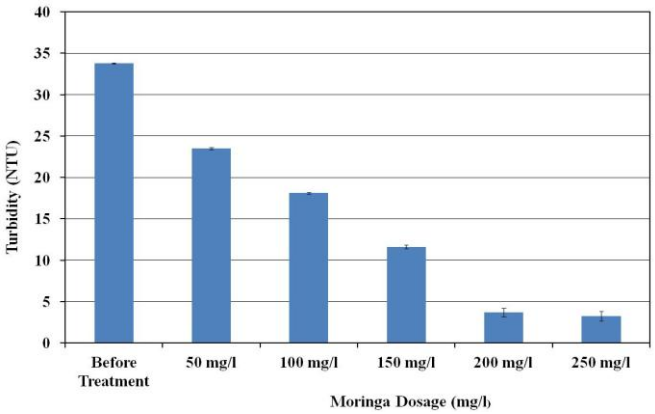

Fig 5: Results obtained for the turbidity measurements conducted on the collected river water before and after treatment using moringa oleifera seed extract at varying dosages

Figure 6 presents the observed trends in the total solids measurements before and after treating the collected river water with moringa oleifera seed extract. Total solids measurements were obtained according to the Standard Method for the characterization of water and wastewater [14]. Total solids measurements were determined by drying to constant weight at 105°C. Trends similar to those of the turbidity results were obtained for the total solids. It was also observed from the statistical analysis conducted using analysis of covariance (ANCOVA) to determine if significant differences exist between the measured total solids of the river water before treatment and after treatment that there were significant differences ($p<0.05$) for each of the moringa oleifera seed extract dosages; however, it was observed that the difference between the effect of the moringa dosages at 200 mg/l and 250 mg/l on the total solids of the river water before treatment was not statistically significant ($p>0.05$). There was a significant decrease in the measured total solids before and after treatment with increasing dosages of moringa oleifera seed extracts. The initial total solids measured in the collected river water was at 650 mg/l and after treatment with moringa oleifera seed extracts at varying dosages, the total solids ranged between 350 mg/l and 58 mg/l. The obtained total solids results indicate about 70% reduction in the initial total solids present in the river water after treatment with moringa oleifera seed extract.

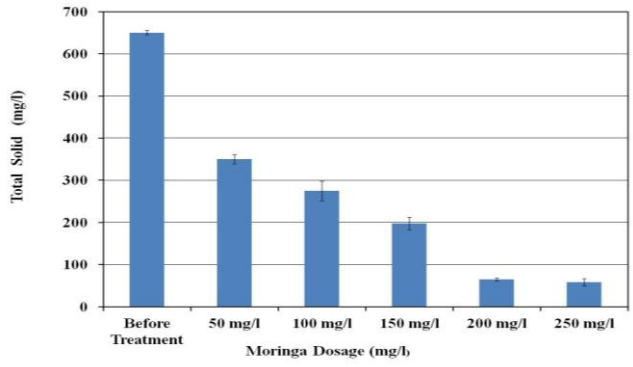

Fig 6: Results obtained for the total solid measurements conducted on the collected river water before and after treatment using moringa oleifera seed extracts at varying dosages

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IV. CONCLUSIONS

The findings from this research demonstrate that the use of moringa oleifera seed extract is highly effective as a natural coagulant for water treatment. Research results showed that the pH and conductivity of the river water after treatment with moringa oleifera seed extract at varying dosages were not affected. The pH of the river water collected before treatment was within the neutral pH range, and after treatment for all the conducted runs, the pH remained within neutral pH range, not significantly different from the pH of the river water before treatment. This observation reinforces the findings from previous studies investigating the viability of moringa oleifera seed extract for the treatment of turbid water [8], [12]. The use of moringa oleifera seed extract as a natural coagulant maintains the neutral state of water after treatment. Hence, the use of moringa oleifera seed extract could be more suitable and have a distinct advantage over the use of chemical coagulants such as alum in water treatment for rural communities in developing countries. This is attributed to the fact that the use of alum and other available chemical coagulants in water treatment affect the pH of the water, leading to high water acidity and thereby raising concerns related to public health issues as documented in previous studies [15],[16].

A notable observation of this study is the ability of the moringa oleifera seed extract to significantly reduce the water turbidity as well as the number of total solids present in the collected river water. It was revealed that reduction in turbidity and in the number of total solids in the river water increased significantly at increasing dosages of moringa oleifera seed extract. It was observed that effective removal of turbidity and reduction in the number of total solids was observed at a higher dosage of 200 mg/l of moringa oleifera seed extract. An overall turbidity removal of approximately 90% and total solids reduction of approximately 70% was observed. Thus, moringa oleifera seed extract exhibits beneficial coagulating properties for the treatment of highly turbid water, and particularly since the pH of the water is not adversely affected by treatment with moringa oleifera seed extract, this treatment is rendered environmentally friendly, a cost-effective alternative to the use of chemical coagulants, as these typically require pH adjustment after treatment, a quite expensive process.

It should, therefore, be concluded from this research that moringa oleifera seed extract is a suitable natural coagulant for improving water quality, serving as an alternative to chemical coagulants such as alum in rural communities in many developing countries.

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