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The Use Of Immobilized *Stereospermum-Kunthianum* Stem-Bark As Natural Coagulant For Treatment Of Waste Water

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Abstract

The high cost of treated water makes most people in the rural communities resort to drinking water from sources of low quality exposing them to water borne diseases.It is in this regard that this research was carried out to confirm the effectiveness of using Immobilized *Stereospermum kunthianum* stem-bark for water treatment/purification which is a plant commonmly found in most rural communities of Biu in Borno state.The plant stem-bark was immobilized by entraping or caging the biomass within a polymeric matrix of sodium alginate and calcium chloride solution to obtaine immobilized *Stereospermum kunthianum* (IMSB). The precipitated blend solid was dried at room temperature. Coagulation was done by using loading doses of 2g, 4g, 6g,8g, and 10g of dried IMSB in a beaker containing 500ml each. A control (Beaker of water without IMSB was also included).Turbidity, Conductivity, pH and antimicrobial activities were determined for all the various doses.The turbidity value of the treated water using IMSB ranges from $Log_{10}0.30$ to $Log_{10}1.36$ while conductivity value ranges from $Log_{10}2.29$ to $Log_{10}2.72$us/cm and the pH values for the treated water was7.2 to 7.8. All values obtained for treatment using IMSB gave values that are accepted according to World Health Organization (WHO) guideline for safe drinking water. The crude extract of the plant exhibit considerable level of inhibition against all test organisms. The result obtained from the use of immobilized *Stereospermum kunthianum* as coagulating agent show significant reduction of turbidity and conductivity, pleasant taste of water, no alteration in pH value of treated water and inhibit the growth of bacteria.

Key words; *Stereospermum-kunthianum,immobilization,Water,Coagulation, Antimicrobial*

INTRODUCTION

Water covering over 70% of the earth, is undoubtedly one of the most precious natural resource of the world. Without the very presence of water, life on earth will be non-existent. However in spite of such large quantity of water present over the Earth's surface, only 0.4 % is available for use. Ninety seven per cent of the earth's water is the salt water of oceans and

seas whereas most of the remaining 3 percent is captured in polar ice caps, glaciers, atmosphere or underground. Despite so much water being out of reach, still 4, 300,000 cubic kilometers of water is available to sustain the plants, animals and humans living on the planet earth (Nilanjana, 2005).

Growing population, increased economic activity and industrialization has not only created an increased demand for fresh water but also resulted in severe misuse of this natural resource. Water resources all over the world are threatened not only by over exploitation and poor management but also by ecological degradation. According to a survey conducted by UNEP, 20% of world's population lacks access to safe drinking water and 50% of the world's population lacks access to safe sanitation. Further studies by David krantz (2010) show that about 830 million people in South Asia lack access to safe drinking water and more than two billion lack proper sanitation. Polluted water is estimated to affect the health of about 1200 million people and contribute to the death of 15 million children under the age of five every year (WHO, 2006).

With increased industrial growth and urbanization, the volume of domestic and industrial effluent, agricultural waste and urban runoffs is steadily growing. Water bodies have an inherent capability to dilute the pollutants, which enter the system. However, indiscriminate dumping of untreated sewage and chemical wastes directly into rivers, lakes, and drains have made these water bodies unable to cope up with the pollutant load. The steady increase in the amount of water used and wastewater produced by urban communities and industries throughout the world also poses potential health and environmental problems. The contaminated waters disrupt the aquatic life and reduce their reproductive capability (Postnote, 2002).

Color and Turbidity in Wastewater

Wastewater disposal is the major problem being faced by developing countries, like Nigeria presently, only about 5% of the wastewater generated is treated, the rest is discharged as it is into our water bodies. The most commonly faced problem in disposal of wastewaters is their color and turbidity. Finely dispersed suspended and colloidal particles are responsible for the color and turbidity of the wastewaters. Color in water results from the presence of natural

metallic ions, humus, peat materials, plankton, weeds and industrial wastes. Suspended and colloidal matter such as clay, silt, finely divided organic and inorganic matter, and plankton and other microscopic organisms are responsible for turbid waters.

Liquid wastes from paper mills, leather industry effluent have 10 to 20% total solids with a Chemical Oxygen Demand (C.O.D.) content of 25000 to 75000 mg/l. Slaughter house effluent has total suspended solids in the range of 3000 to 4000 mg/l and a COD content of 6000 to 8000 mg/l. The effluent generated by anaerobic digestion of municipal market wastes has 2-3% solids. Wastewaters from textile, food, cosmetic, paper and leather industries contain dyes which being recalcitrant in nature are difficult to degrade. These dyes are highly colored compounds and leads to reduction of sunlight penetration in rivers, lakes or lagoons that in turn decrease photosynthetic activity and reduces the dissolved oxygen concentration (Folkard, 1994). This brings about detrimental effect on the aquatic life.

The Coagulation Process

Coagulation and flocculation are the processes used to remove the particles responsible for turbidity and color. The colloidal particles present in wastewaters generally carry a negative electrical charge. Their diameter may range between $l0^{-4}$ to 10^{-6} mm. These particles are surrounded by an electrical double layer (due to attachment of positively charged ions from the ambient solution) and thus inhibit the close approach of each other. They remain finely divided and don't agglomerate. Due to their low specific gravity, they don't settle out.

COAGULATION

Aluminum and iron salts are commonly used as chemical coagulants. They form Insoluble material ie. aluminum and ferric hydroxides when they react with calcium and manganese hydrogen carbonates, which are almost always present in water. The formation of the insoluble hydroxides depends on the pH. Whereas turbidity is best removed within a pH range of 5.7 to 8.0, color removal is generally obtained at pH range of about 4.4 to 6.0. Alum (aluminum sulphate) is most widely used chemical coagulant whereas ferric chloride, potash alum, ammonia alum, ferrous sulphate are also some of the chemical coagulants which are not extensively used

Earlier research findings of Crapper *et al*.,1973 and Miller *et al*., 1984 showed that the chemicals used for water purification can cause serious health harzards if an error occurs in their administration during the treatment process. These reports suggested that a high level of aluminium in the brain is a risk factor for Alzheimers disease. Studies by Litterman and Driscoll, 1988, Miller *et al*.,1984 have raised doughts about the advisability of introducing aluminium into the environment by the continuous use of aluminium sulphate as a coagulant in water treatment.

USE OF PLANT MATERIALS AS COAGULANT

The use of plant materials as natural coagulants to clarify turbidity of waste waters is of common practice since ancient times. Powdered roasted grains of zea mays were used by soldiers in Peru as a means of settling impurities in the 16^{th} and 17^{th} century. In India, the Nirmali tree (*Strychnos Potatorum*) is used as a water clarifier (Folkard *et al*., 1995).

Of all plant material investigated, Stem-bark of *Stereospermum kunthianum* plant are one of the most effective sources of primary coagulant for water treatment.

The traditional use of *Stereospermum kunthianum* stem-bark for domestic water treatment is a common practice in rural areas of Biu in Borno state , Nigeria. The stem-bark is chopped into pieces and mashed in a motar. The crushed stem-bark is mixed with turbid water that produces positively charged water-soluble proteins. These proteins bind to the suspended particles forming larger agglomerated solids. The flocculated solids are allowed to settle prior to boiling and subsequent consumption of water.

The traditional use of any biomass in its natural form do not harness the effective use of the plant materials. If the biomass is used in its natural form it solves one problem but at the end create other problems. It will help in coagulation of water but other problems such as debris of the plant will flow on the water in which filtration process has to be undertaken before drinking. So also after 48 hours the plant biomass will foul the water (Smelling of water) as a result of decomposition of organic matters in the plant.. There fore the plant sample has to be converted into an industrial product to harness the potential of water purification with out

creating the afore mention problems. For the purpose of this study, the plant stem bark is immobilized in order to cage the biomass within a polymeric matrix.

It is a well established fact as proven in several publications that the quality parameters of drinking water include its **Turbidity, Conductivity, pH** and **Microbial load.**

The main objective of this study is to confirm the effectiveness of processed *Stereospermum kunthianum* stem-bark as water coagulant.

Stereospermum kunthianum plant

Stereospermum-kunthianum belongs to the family *Bignoniaceae*.The plant has vernacular names known by traditional herbalist and the communities where it is commonly found; *SanSami* (Hausa), *Ndengal-mbalu*, (Fulfulde), *Kengyar-tuma* (Babur-Bura), *Kera-thla* (Marghi), *Ayada* (Yoruba), *Alakiriti* (Ibo) and *Umana* (Tiv).

Stereospermum kunthianum is found in dry areas of deciduous forest, woodland,bush, rocky outcrops, termite mounds and margins of evergreen forests. The species is well spread all over the Sahel region and is often found near streams. Geographic distributions include Nigeria, Democratic Republic of Congo, Djibouti, Eritrea, Ethiopia, Kenya and Mozambique.

Biophysical limits Altitude **:** 500-2400 m, Mean annual temperature **:** Up to 40 ^{O}C, Mean annual rainfall **:** 450-900 mm. Soil type **:** Grows well on light silty and sandy soils. Reproductive **;** the bisexual flowers appear in the dry season before the new leaves, between February and March, and pods ripen between April and May (Aliyu Babayo, 2011).

Stereospermum kunthianum is a multipurpose plant of significant importance to local communities. According to traditional healer in Biu, Borno Nigeria (Bulama Fori, 2013), one of the major uses of the plant is in the treatment/purification of water by local communities where the plant is found. The plant has numerous uses to the local communities where they are found. The plant leaves are used as feeds to animals (cattles, sheeps, and goats). It has repellant property. The stem and roots of the plant if boiled and allowed to cool or if soaked in cold water over night could be used in the treatment of some illness (Fori, 2013).

MATERIALS AND METHODS

Materials

The materials needed for this experiment are : Sodium-alginate, Calcium-chloride, Hydrochloric acid, Sodium-hydroxide. These chemicals were of analytical grade and were used as supplied. *Stereospermum kunthianum* stem-bark was obtained from creek in Waka-Biu, Borno State Nigeria.

Methods

Sample Preparation

The stem bark sample were freed from sand particles and dead dried tissues by carefully scraping with spatula. It was chopped to pieces, air dried for two weeks, then milled into powder using pestle and motar. The pulverized sample was stored in paper bag for further analysis (Osemeahon *et al*., 2007).

Dissolution of Plant Samples

The dissolution of the *Stereospermum kunthianum* stem was done by weighing 4.00 g of the stem bark powder and dissolved in 100 cm^3 of water, then the mixture was poured into a separating funnel and allow to stand for 12 hrs to observe the possible separation into various fractions (Osemeahon *et al*., 2007).

Preparation of Sodium Alginate and Calcium Chloride to Immobilized Sample

Sodium alginate was made by weighing 4.00 g and making it up to 100 cm^3 mark with distilled water in a volumetric flask and allow overnight for complete dissolution to give 4% w/w.

Calcium chloride (0.12 M) was prepared by weighing 26.28 g into 1L volumetric flask and make up to the mark with distilled water (Wuyep *et al.*, 2007).

Synthesis of Immobilized Samples of *Stereospermum kunthianum*

25 cm^3 viscous layers of dissolved *Stereospermum kunthianum* stem bark sample were mixed with 25 cm^3 of 4 % stock solution of sodium alginate and stir vigorously for even mixing in 250 cm^3 beakers. The mixture was then transferred into another beaker

containing 30 cm^3 of 0.2 M Calcium chloride solution. The reaction was allowed retention time of 1 hour for complete precipitation. The precipitate blend solid of the stem sample was filtered and dry at room temperature (30^0C) for 24 hrs. The dried solid was stored in polyethylene bag for further use (Wuyep, *et al.*, 2007).

Immobilization of *Stereospermum kunthianum* Stem-barks

The immobilization of *Stereospermum kunthianum* stem-bark was achieved by entrapping or caging it within the polymeric matrix of Sodium alginate. It has been established that Sodium alginate consist of L-guluronic acid and D-manuronic acid units (Nancy and Mwaisumo,2008). The contacting of Ca^{2+} ions with gulunoric acid block forms an ionically cross-linked structure in aqueous environments. The cross linking of the polymer is due to binding of divalent cations (Ca^{2+}) to the carboxylic ($-COOH^-$) group of L-guluronic acid block (Mary *et al.*, 2005). Divalent cations act as a cross-links and cause an ionic binding between G-blocks in polymer chains and forms three dimensional network (Naghan and Ageena, 2010). This network mobilizes *Stereospermum kunthianum* bark to produce a biosorbent.

Laboratory Analysis

Raw water was collected from waka-creek in Biu Borno state Nigeria. Colour and pH were measured. Six one litre beakers were marked and placed on a table. 500cm^3 of the raw water poured into each beaker. 2g, 4g, 6g, 8g and 10g of immobilized Stem-bark were added into the beakers in increasing order respectively (A beaker without immobilized plant stem bark as control was also included). They were shaken on a shaker for five minutes. The flocs formed are allowed to settle and the time taken for each beaker to settle completely was noted.

Jar Test

The jar test was used. Various mass of the immobilized Stem-bark of *Stereospermum kunthianum*Stem-bark, 2g, 4g, 6g, 8g and 10g were put into a beaker containing 500 ml of the pond water. The solutions were mixed rapidly for 2 minutes, followed by 10 minutes of gentle mixing using glass rod to aid in coagulant formation. The suspensions were left to

stand without disturbance for one hour. And the time taken for coagulation to take place in the various beakers was recorded. This is the method adopted since there is no standard method for conducting the jar test (Francis and Amos, 2009). The supernatant formed were decanted and subjected to **Turbidity, pH** and **Conductivity** measurements.

pH Measurement

The pH of the sample was read using a calibrated pH meter. A volume of 200 ml of the supernatants obtained from the beakers containing the treatments was measured into a beaker. The pH meter probe was then inserted making sure it did not touch the beaker. The pH reading was then taken after it had stabilized.

Conductivity Measurement

The sample used for the pH measurements were used for the conductivity test. A calibrated Crison Conductimeter was used. The conductivity meter probe was then inserted making sure it did not touch the beaker. The reading was recorded from the LCD displayed after it had stabilized

Turbidity Measurement

This was carried out on supernatants obtained after the treatments have been administered into the beakers containing the pond water. Direct reading spectrophotometer from Superlink Digital Turbidity Meter Model 033G was used. This is a multipurpose spectrophotometer. It was configured to read turbidity at the wavelength of 750 nm specified for measuring turbidity. Distilled water was first poured into a 25 ml cuvette and inserted into the spectrophotometer to act as the control. The calibration button was pressed and the instrument was then calibrated. Each of the samples to be read was poured into a 25 ml cuvette and inserted into the spectrophotometer. The turbidity of the samples was displayed on the LCD panel of the instrument in Nephelometric Turbidity Units (NTU). After each reading, the spectrophotometer was calibrated again with the distilled water before being used on the next sample.

RESULTS AND DISCUSSION

Turbidity

From the results below, the turbidity values range from $\log_{10}0.30$ NTU to $\log_{10}1.36$ for all the treatments used. The declared WHO guideline for conductivity provided for safe drinking water is 5 NTU ($\log_{10}0.700$ NTU) (WHO,2006). The 2g to 10g of treated *Stereospermum kunthianum* Stem-bark recorded values that were acceptable according to the WHO (2006) guidelines for drinking water. As expected, the control treatment gave the highest turbidity value of $\log_{10}2.32$ NTU. It is clearly seen that higher concentrations of immobilized *Stereospermum kunthianum* stem-bark of 10 g/500 ml loading dose as coagulant gives a good effect on turbidity. This shows that immobilized Stem-bark can be adopted for water purification. This is likely to lead to cost reduction in the conventional water treatment using alum and no threat to human life in case of overdose as stated in the findings of Crapper *et al*., (1973).The method of allowing water to settle without any coagulant is not efficient as proven by the treatment results. The result of this study shows that the quality of water for consumption for rural communities can be improved by first adding immobilized Stem-bark before the general recommended "boil before use" strategy.

Treatment Dose (g)	Turbidity (NTU)
0	$\text{Log}_{10}2.32$
2	$\text{Log}_{10}1.24$
4	$\text{Log}_{10}1.20$
6	$\text{Log}_{10}0.28$

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8	$Log_{10}0.26$
10	$Log_{10}0.24$

Conductivity

Conductivity which is a measure of total dissolved solids (TDS) in water varies considerably in different geographical regions owing to differences in the solubility of minerals, hence there is no standard value for it but high levels in drinking water may be objectionable to consumers (WHO, 2006). The conductivity range from $log_{10}2.29$ to $log_{10}2.72$ uS/cm for varying concentration of all the coagulants used. The conductivity value of $log_{10}2.72$ uS/cm recorded for the control was extremely high indicating the presence of dissolved impurities. This indicates that turbid water which is allowed to stand with no treatment is an inadequate procedure for removing dissolved and floating particles. It could be efficient if the turbid water is left to stand for a very long time. The conductivity measurements followed a similar pattern as the turbidity measurements. Increasing concentration of immobilized Stem-bark led to decrease in conductivity values. It can be deduced that higher loading dose other than the ones used in this work can be adopted to decrease water conductivity and turbidity in water meant for consumption in most rural communities. The immobilized Stem-bark treatment values ranged from $log_{10}2.34$ to $log_{10}2.50$ uS/cm.

Treatment Dose (g)	Conductivity (uS/cm
0	$Log_{10}2.72$
2	$Log_{10}2.60$
4	$Log_{10}2.42$

6	$Log_{10}2.36$
8	$Log_{10}2.24$
10	$Log_{10}2.21$

pH

The recommended acceptable range of pH for drinking water specified by WHO (2006) is between 6.0 and 8.0. The treatments gave a range of 7.2 to 7.8 which falls within the specified range. As the concentrations of the dosing solutions were increased, the pH increases with increasing concentration of the immobilized Stem-bark coagulant. Francis *et al*., (2009) reported that the action of a coagulant lies in the presence of water soluble cationic proteins in the plant. This suggest that in water, the basic amino acids present in the proteins of the stem-bark would accept a proton from water resulting in the release of a hydroxyl group making the solution basic. This accounted for the basic pH values observed for the stem-bark treatments.

The *Stereospermum kunthianum* stem-bark may contain lower weight water-soluble proteins which carry a positive charge. When the stem-bark is added to water, they produce positive charges acting like magnets and attracting predominantly negatively charged particles such as clay, silk, and other toxic particles. Under proper agitation, these bound particles then grow in size to form the flocculates which are left to settle by gravity. This accounted for the effectiveness of *Stereospermum kunthianum* stem-bark for raw water purification.

Treatment Dose (g)	pH
2	7,20

4	7.30
6	7.40
8	7.50
10	7.60

Antimicrobial Analysis

The test organisms used include five bacteria (*Salmonella typhi*, *Staphylococcus aureus*, *Escherichia coli*, *Streptococcus pneumonia* and *Pseudomonas aeruginosa*).These test organisms were obtained from the National Veterinary Research Institute (NVRI), Vom, Plateau State. The choice of these pathogens was based on their implication in human diseases such as typhoid fever, pneumonia, urinary tract infections, jaundice, skin problems, dysentery and diarrhoea. The agar plates (nutrient agar) were prepared and inoculated by spreading a small volume (0.05 ml to 0.10 ml) of the liquid inoculums (sub-cultured nutrient broth) by means of an L-shaped glass rod (a-'' spreader'') in such a way that the surface of the agar in the plates were covered with the microbes. One microbe was inoculated to one plate making a total of seven plates for seven microbes. After about 30 minutes, seven wells were punched on each plate using a sterile cork borer of 5 mm diameter. Five wells for petroleum ether, ethyl acetate, acetone, ethanol and water extracts; one for negative control substance (distilled water).

A 0.1 ml of each extract from each solvent (equivalent to 200 mg) was dropped into each appropriately labelled well. In the control no substance was introduced. The inoculated plates were left on the table for about an hour to allow for proper diffusion. Nutrient agar plates were incubated aerobically at 37^0C for 24 hours. The diameter of the zones of inhibition produced after incubation was measured by means of linear instrument in millimetre and recorded. (Reuben *et al*.,2008).

Results and Discussion

The result obtained for the in vitro antimicrobial activities of the crude extracts reveals that, the 200mg concentration of the water and ethanol extracts exhibit reasonable antibacterial activities against *Escherichia-coli,Salmonella-typhi, Staphylococcus aureus, Streptococcus pneumonia* and *pseudomonas aeruginosa* (20 to 28 mm diameter zone of inhibition) at equivalent concentration. The minimum inhibitory concentration (MIC) of the extracts against tested bacteria ranged from 200 to 25 mg/ml. MIC of 25 mg/ml and 50 mg/ml appear to be the most active which correspond to water and ethanol extracts.

Conclusion and Recommendations

The antimicrobial activities of the extracts were tested against some clinical isolates and the results obtained showed that ethanol and water extracts gave reasonable inhibition against *Salmonella typhi, Escherichia coli, pseudomonas aeruginosa* and *Candida albicans* with minimum inhibitory concentration ranges from 25 to 50 mg/ml considered to be the most active extracts. The result of this piece of work corroborates the claim that *Stereospermum kunthianum* Stem-bark is used to treat some bacteria associated disease like typhoid fever, skin rushed, stomach constipation, and diarrheal among others

CONCLUSION

The results obtained from the use of *Stereospermum kunthianum* as coagulating agents show:

- Significant reduction of turbidity and Conductivity
- Pleasant taste of treated water
- No alteration in pH value of treated water
- Initial reduction of bacteria! count

Tannins, essential oils, sap or adhesive agents contained in plants are the active agents that bring about coagulation. Natural polymers such as starch, gums, glues, alginates, etc., function as bridging flocculants. Investigations of *Stereospermum kunthianum* Stem-bark have revealed that the coagulant properties is due to a series of low weight cationic proteins.

Because of their effectiveness in waste water treatment. The technology involved are economical, traditional and easy to implement and ideal for rural areas. The process being

biological in nature does not generate any non-treatable wastes. These processes are easy to operate and require little or no maintenance.

For future development of the use of plant materials for waste water treatment, other native plants and plant materials should be investigated as coagulant for color and turbidity removal. Future studies should focus upon the dosage of these materials to be used in water treatment. Efforts should be made to make these traditional technologies, which is already being used in rural areas, recognized and accepted globally.

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