Organic coagulants as turbidity removal in water treatment and their toxicity to freshwater fauna: A review

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ABSTRACT

Water that is free from toxicants ('safe water') is essential to farmers and aquatic life. Globally, synthetic coagulants are issue of public health concern due to their longterm and non-biodegradable effects on human and aquatic life. The synthetic coagulants have been implicated in the causes of Alzheimer, cancer and bioaccumulation along food chain in aquatic environment. However, the world is tending towards organic products to promote her health safety due to environmental friendliness of organic based products to human and aquatic health. There has been considerable interest in the use of natural coagulants in water treatment prior to supply of water to the community. Organic coagulants are biodegradable, cost-effective and environmental friendly compare to the synthetic coagulants used in water treatment as turbidity removal. The preparation of water supply to public as potable water requires a lot of treatments which include coagulation and clarification of suspended particles. However, aquatic ecosystem is the final receiving body at risk of toxicants exposure due to their toxicity effects on fish and non-target species organs and tissues. Their toxicity level to aquatic and non-target organisms is essential for baseline information on the dosages that will not be harmful to aquatic life. This paper therefore reviewed some available organic coagulants in public water treatment, their level of toxicity to different freshwater fish species and non- target aquatic fauna, health implication on consumers of fish exposed to these coagulants. Public recommendations on their uses and health implications were addressed.

Key words: *Organic coagulants, water treatment, turbidity, toxicity, fish, non-target species.*

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INTRODUCTION

Water is life to human and aquatic splendour. No living creatures can survive without the liquid gold, which supports life. Water that is free from toxicants ('safe water') is essential to human and aquatic life in inter-land. Some 1.1 billion people lack access to clean water and about 2.6 billion people lack access to basic sanitation (Muyibi,2005;Tearfund,2007). In Africa,an estimated 5 percent of Gross Domestic Product (GDP) is lost to illiness and deaths caused by dirty water and the absence of sanitation (Tearfund,2007; Miller *et al.,*2008). More than 300 million people in Africa drink dirty water everyday (Muyibi,2005; UNESCO/WWDR, 2006; Adesina *et al.,* 2008). Access to safe water is a basic human need but unavailable to several millions of people in the developing world .However, public water supply needs to undergo different stages of treatment before supply to the people (Adesina *et al.,* 2008). Coagulation is one of the water treatment process and plays one of the important roles in water treatment (Das *et al.,* 2005). One of the commonly used coagulants in water treatment are the synthetic coagulants which include alum, ferric sulphate and other synthetic polymers (Litherland, 1995; Oluwalana *et al.,* 1999; Miller *et al.,* 2008; Adesina *et al.,* 2008).

Globally, synthetic coagulants are issue of public health concern in water treatment to human and the fate of aquactic life is at risk due to their longterm and non-biodegradable effects on human and aquatic animals.

The synthetic coagulants have been implicated in the causes of Alzheimer, several medical disorders, Cancer in human and bioaccumulation along food chain in aquatic environment (Schwarz, 2000; Mbogo, 2008; Miller *et al.,* 2008; Adesina *et al.,* 2008). This later resulted in reproductive dyfunction, impaired growth and often led to death of aquactic animals. However, the world is tending towards organic products to promote her health safety and environmental sustainability; due to environmental friendliness of organic based products to human and aquatic life.

There has been considerable interest in the use of natural coagulants in water treatment prior to supply of water to the community. Natural coagulants are biodegradable, cost-effective and environmental friendly compare to the synthetic coagulants used in water treatment as turbidity removal and micro-organisms. The preparation of water supply to public as potable water requires a lot of treatments which include coagulation and clarification of suspended particles.

However, little attention is paid to the aquatic ecosystem,which is the final receiving body at risk of toxicants exposure due to their toxic

effects on fish and non-target species organs and tissues. The toxicity level of natural coagulants to fishes and non-target organisms is essential for baseline information on the dosages that will not be harmful to aquatic life. Since, human considered some of the aquatic life as sources of food in form of protein and their right to live in free non- polluted aquatic ecosystem is a must for continuity of sustainable food chain in aquatic body.

This paper therefore reviewed some available natural coagulants in public water treatment, their level of toxicity to different freshwater fish species and non- target aquatic fauna, health implication on consumers of fish exposed to these coagulants. Public recommendations on their uses and health implications were addressed.

Organic Coagulants in Water Treatment

In developing countries, such as Nigeria, Ghana, Togo, and Benin; water treatment plants are expensive and ability to pay for services is minimal and applied technology is scarce (Nkhata, 2001; Adesina *et al.,* 2008). Natural coagulants have been found to be cost-effective, biodegradable and environmental friendly (Muyibi and Evison, 1995).

These coagulants does not modify the pH of water, and produce low volume of sludge precipitated is biodegradable (Schwarz, 2000). Naturally occurring coagulants are usually presumed safe for human health (Muyibi, 2005), but aquatic health should be put into consideration when using them in water treatment at pilot scale water scheme.

Check-list of Potential Organic Coagulants in Water Treatment

Some studies on natural coagulants have been carried out and various natural coagulants were produced or extracted from microorganisms, animals and plants (Ghebremichael, 2004; Muyibi, 2005; Yongabi, 2005; Adesina *et al*., 2008; Miller *et al.,* 2008; Mbogo, 2008). The table1 below shows the list of potential natural coagulants used in water treatment.

Some of these natural coagulants with their extracts have been widely used in coagulation of water since ancient time, and appears to be an effective and accepted physical-chemical treatment for household water in some parts of the world (WHO, 2006).The awareness about them is low in Nigeria and need urgent attention at household level. Most of the researches done on some of them are still at the preliminary stages, there is need for large-scale pilot study at different water treatment scheme in the developing world. In particular, extracts from seeds of *Moringa* species, the trees of which are widely present in Africa, the Middle East and the Indian subcontinent, have the potential to be an effective, simple and low-cost coagulant-flocculent of turbid surface water that can be implemented for household water treatment (Jahn and Dirar, 1979; WHO, 2006).

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The effectiveness of another traditional seed or nut extract, from the nirmali plant or *Strychnos potatorum* (also called the clearing nut) to coagulate-flocculate or precipitate microbes and turbidty in water also has been determined (Tripathi *et al*.,1976; WHO, 2006). Microbial reductions of about 50% and 95% have been reported for plate count bacteria and turbidity, respectively. Despite the potential usefulness of *Moringa oleifera, Strychnos potatorum* and other seed extracts for treatment of turbid water, there has been little effort to characterize the active agents in these seed extracts or evaluate the efficacy as coagulants in reducing microbes from waters having different turbidities (WHO, 2006).

The presence of other constituents in these seed extracts is uncertain, and there is concern that they may contain toxicants, because the portions of the plant also are used for medicinal purposes (WHO, 2006; Miller *et al*., 2008; Adesina, 2008; Adesina *et al*., 2008). Also little has been done to define, optimize and standardize conditions for their use. Furthermore, there appears to be little current effort to encourage or disseminate such treatment for household water or determine its acceptability, sustainability, costs and effectiveness in reducing waterborne infectious disease (WHO, 2006).

Botanical Name	Part to be used in water Treatment	Source of natural coagulants
Moringa oleifera Lam.	Seeds, Husk	Plant
Moringa stenopetala	Seeds, Husk	Plant
Arachis hypogeal	Pounded seeds	Plant
Balanites aegyptiaca	Bark	Plant
Caparis deciduas(Forsk)	Branches	Plant
Salix subserrata wild	Leaves	Plant
Cyperus rotundus (L.)	Rhizome	Plant
Tamarix nilotica	Branches	Plant
Adansonia digitata	Pounded seeds, Fruit pulp	Plant
Strychnos potatorum(Linn)		
Nirmali tree	Seed	Plant
Opuntia tuna	Leaves, Mucilage	Plant
Opuntia ficus indica	Leaves, Mucilage	Plant
Opuntia latifolia	Leaves, Mucilage	Plant
Tetracarpidium conophorum	Seed, Husk	Plant
Glycine max	Seed,	Plant
Zea mays	Seed	Plant
Vigna unguiculata(L.) Walp	Seed	Plant
Hibiscus esculentum	Seed, Root, Sap	Plant

Hibiscus sabdariffa	Seed, Flower, Calyx	Plant
Euphorbia tirucalli	Latex	Plant
Phaseolus mungo	Seed	Plant
Phaseolus vulgaris	Seed	Plant
Citrus mitis	Fruit juice	Plant
Pisum sativa	Seed	Plant
Calotropis procera	Seed, Latex, Leaves	Plant
Jatropha species	Seed, Latex, Leaves, Stem	Plant
Cassia angustifolia	Seed	Plant
Cajanus indicus	Seed	Plant
Eichhornia crassipes	Root	Plant
Crab/crayfish	Carapace/chitosan	Animal
Achatina species	Shell	Animal
Burn trees	Charcoal, wood ash	Plant waste product
Percica vulgaris	Seed	Plant

Toxicity of Organic Coagulants to Freshwater Fish Species and Non- target Aquatic Fauna

Whenever water is been treated with the coagulants at the water treatment scheme, no effort is made to consider the fate of aquatic organisms in the large water body such as rivers and streams which is the final receiving body of these coagulants. However, human considered some of these aquatic fauna as source of protein to every household. Some of these natural coagulants have been tested on some of these aquatic fauna and their toxicity levels have been established. More research has to be done on other natural coagulants. The table 2 below established toxicity level to aquatic fauna.

Table 2: Test Concentrations used on Aquatic Fauna from different Organic Coagulants

Organic Coagulants		Test concentration (ml/l) or (mgl^{-1})**		
Scientific Name *Moringa oleifera(Lam.)*	Part used Seed	Nile tilapia Fingerlings 0,38,69,123,222,400** Juveniles 0,57,102,185,333,600**	Mosquito fish —	Water snail* –
Citrus mitis (Blanco)	fruit juice	0,0.5,1,2,5,10 0,	0.5,1,2,3,5	–
Jatropha curcas	stem	0,5,10,14,20,30	0,20,50,60,80,90	–
Euphorbia tirucalli	latex	–	–	1.90** *Lymnaea acuminata* *3.95*** *Indoplanorbis Exustus*

Source: Tiwari *et al*., 2003; Cagauan *et al*., 2004; Adesina, 2008)

* Water snail as non-target species.
* Fish and snail exposed to Mgl^{-1} concentrations.

Based on 96-h lethal concentration (LC_{50}), the natural coagulants exerted piscicidal activities on Nile tilapia and mosquito fish as follow: *Moringa oleifera* seed LC_{50} values on fingerlings and juveniles, respectively as 196.24 and 285.71$mgl^{-1.}$ While *Citrus mitis* gave LC_{50} 3.12 ml/l on Nile tilapia and 2.38ml/l for Mosquito fish. However, *Jatropha curcas* gave 12.80, 28.57 for Nile tilapia and mosquito fish respectively (Cagauan *et al*., 2004; Adesina, 2008). All fish species used in these exposures were of equal size and age for toxicity validation purpose. The latex of *Euphorbia tirucalli* exposed *to* water snails as non-target species,*Lymnaea acuminata* and *Indoplanorbis exustus* gave the LC_{50} at 24-h as 0.51mgl^{-1},0.55mgl^{-1} respectively (Tiwari *et al*., 2003).The exposure of the two snails to the latex extracts increases mortality of the snail, *Lymnaea acuminata* to 95% while *Indoplanorbis exustus* mortality was 96% which shows that the latex is more toxic to the snail *Indoplanorbis exustus* (Tiwari *et al*.,2003).

Health Implication on Consumers of Fish Exposed to these Coagulants.

Globally, use of organic products is being embraced in aquaculture due to their safety and environmental friendly approach to human. However, most of the organic piscicides used in aquaculture as pond management tools are of organic based. Some of them possess coagulation-flocculation property and are of medicinal uses. Many plants from different families have been applied for catching fish all over the world (Cagauan *et al*., 2004). The botanical piscicides are suggested as best alternatives to synthetic materials because of their easy availability, biodegradability, greater effectiveness, less expensive, lower toxicity against non-target organisms, and their comparative safety toward the environment and human beings (Marston and Hostettmann, 1985; Cagauan *et al*., 2004). Fish killed by botanical piscicides can be consumed by human without ill-health effects (Chiayvareesajja *et al*., 1997). In brief, natural coagulants been used in aquaculture to purifying turbid water in fish culture enclosures should not be indiscriminately used to avoid mass mortality in fish pond stocked with desirable fish species.

Public Recommendations on their uses and Health implications

The results of several studies on natural coagulants to be applied at household level to improve the microbial quality of water and reduce

waterborne transmission of diarrhea disease in developing countries is a new development when compare to the synthetic coagulant such as alum(WHO, 2006).The following recommendation are proposed on the use of natural coagulants in water treatment.

- There is the need to optimize and characterize the active agents in natural coagulants in reducing microbes from waters having different turbidities.

- There is the need to encourage the dissemination of natural coagulants in household water treatment especially in rural communities where turbid water is common due to lack of potable water.

- There should be adequate information on the dosages needed to reduce microbial loads of turbid water.

- The Ministry of Environment, Water Corporation boards at all levels and State Department of Fisheries, Research Institutions relating to water issue and local community should be adequately involved when developing environmental frame work and guidelines on the use of natural coagulant in water treatment.

- Federal Ministry of Health should be involved in the formulation of health policy on the use of organic coagulants in public and household water treatment.

- Acceptable guidelines should be put in place to know the exact amount of organic coagulants to be discharge into aquatic body so as to protect the aquatic fauna.

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