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Utilization of *Citrus sinensis* seeds in purification of water from Challawa George Dam in Kano Nigeria

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Abstract This study was designed to evaluate the activity of *Citrus sinensis* seed extract on tap water source from Kano State, Nigeria. *Citrus sinensis* seed wings were removed and the kernels were ground to a fine powder. Different concentrations of *Citrus sinensis* seed solutions were made by dissolving 1g, 3g, and 5g of the *Citrus sinensis* seed powder in to a 100mls of distilled water each contained in a conical flask to obtain 1%, 3% and 5% concentrations respectively. Physicochemical parameters such as turbidity, conductivity, temperature, pH and total dissolved solid (TDS) were determined before and after treatment of the water samples. Five percent seed extract solution show greater effect than 3% and 1% respectively. The decrease and increase in physicochemical parameters before and after treatment with 5% showed turbidity (514±22.91 vs 52.90±8.29NTU), conductivity (45±6.00 vs 209±21.52 µS/cm), pH (8.90±0.20 vs 6.25±0.25), temperature (27.60±3.70 vs 28.70±1.20^{0}C) and TDS (30.0±2.30 vs 170±6.40ppm) respectively. Therefore, *Citrus sinensis seed* could be regarded as water treatment agent, which can provide remedy to the incidence of water borne disease leading to high incidence of death in the developing world.

Keywords Citrus sinensis seeds, purification, Kano-Nigeria.

Introduction

Water is used for several purposes by humans, but the level of purity of the water consumed is very crucial since it has a direct effect on health [1]. Currently drinking water sanitary practices depends on a number of chemical compounds, such as chlorine, fluoride, ozone and polyacrylamides used as disinfectants and/or coagulants [2]. Every year, billions of people lack availability of safe drinking water which eventually turns into a big reason of mortality especially among young age groups from fatal diseases like diarrhea [3]. The conventional method of water purification using aluminum sulphate (alum) and calcium hypochlorite add chemicals to drinking water which are considered potentially hazardous to human health at relatively high concentrations [1].

Coagulation and flocculation are two most important physicochemical treatment steps to reduce the suspended and colloidal materials responsible for turbidity of the wastewater and also for the reduction of organic matters which contributes to the Biological Oxygen Demand (BOD) and Chemical Oxygen Demand (COD) content of the wastewater [4]. In developing countries, most of the chemicals used in water purification and production are imported thereby making it expensive and beyond the reach of most people in rural areas [5]. We are presenting, for the first time, *Citrus sinensis* seeds as an alternative, safe, inexpensive and easily available means to chemical substances for removing turbidity and colour from tap water source in the most populated state of West African sub region.

Materials and Methods

Preparation of *Citrus sinensis seed* suspensions and extract

*Citrus sinensis seed*s used were collected from the Kano State Agricultural and Rural Development Authority (KNARDA). The seed wings were removed and the kernels were ground to a fine powder using domestic food blender. Different concentrations of *Citrus sinensis* seed solutions were made by dissolving 1g, 3g, and 5g of the seed powder into a 100mls of distilled water each to obtain 1%, 3% and 5% concentrations respectively. The solution was shaken vigorously for 1 minute to extract and activate the coagulant in the seed powder. Each of the concentrations was poured into one litre of the raw water contained in a beaker (2 litre capacity) and the water stirred extensively for 60 seconds and then slowly for 2 minutes. The treated water was then allowed to stand undisturbed for 12 hours. After which 100mls was collected from the top of the water and subjected to post treatment analysis [6].

Treated water

Treated water was obtained from the Challawa Water Treatment Plant, Kano state, Nigeria. The water sample was collected between 6-8am using sample containers, collection were done at different location of the dam.

Results and Discussion

Table 1: Physicochemical parameters of treated water with *Citrus sinensis* seeds from Challawa Gorge Dam, Kano State, Nigeria

Parameters	Unit	Treatments			
		Raw water	**1%**	**3%**	**5%**
Turbidity	NTU	514.00±22.91a	146.00±18.03b	70.30±17.39c	52.90±8.29d
Conductivity	µS/cm	45.00±6.00e	121.00±8.00f	161.00±19.70g	209.00±21.52h
pH	-	8.90±0.20i	7.50±0.44j	6.53±0.03k	6.25±0.25l
Temperature	^{0}C	27.60±3.70m	28.70±2.20n	28.80±2.05o	28.70±1.20p
Total Dissolved Solid	Ppm	30.00±2.30q	100.00±12.40r	130.00±13.50s	170.00±6.40t

Values are mean±S.D., values on the same row with the different letters are considered significantly different ($p<0.05$).

The physicochemical parameters of treated water from Challawa Gorge Dam, Kano State, Nigeria is presented in Table 1. From the results, the turbidity of the water sample before treatment with *Citrus sinensis seed*s extract was found to be 514±22.91 NTU. After treatment of the water with 1g/L, 3g/L and 5g/L of the seed extract, turbidity decreased to 146±18.03, 70.3±17.39 and 52.9±8.29NTU respectively. This clearly indicates that turbidity decreases significantly ($p<0.05$) with increase in concentration of the seed extract. This effect of *Citrus sinensis seed* extract in decreasing water turbidity indicated that the suspension has a clarifying potential, which could be attributed to the inherent bioactive component of the seeds. These bioactive compounds could as well be water soluble proteins carrying positive charges that attach/bind themselves with the impurities in the water samples having predominantly negative charge as earlier suggested [1]. Clear water is usually considered an indicator of healthy water [7]. Water clarity is directly related to turbidity, as turbidity is a measure of water clarity [8].

It was cautioned that a sudden increase in turbidity in a previously clear body of water is a cause for concern [9]; it can inhibit photosynthesis by blocking sunlight, resulting into decreased plant survival and decreased dissolved oxygen output [10]. Increased in turbidity can often indicate potential pollution [11], not just a decrease in water quality [12], contributing to high level of water contaminants such as bacteria, protozoa, nutrients (e.g. nitrates and phosphorus), pesticides, mercury, lead and other metals [13]. Recommended levels were set for turbidity in drinking water below 0.2 NTU, with a mandatory maximum of 1 NTU for drinking water [14].

According to the [15], water for human consumption should have turbidity levels below 1 NTU, though for some regions, up to 5 NTU is allowed if it can be proven to be disinfected [15]. The American Water Works Association suggests that a level of 5 NTU or lower is acceptable for recreation purposes [16]. The North Carolina code allows up to 10 NTU for trout waters, 25 NTU for non-trout streams and as high as 50 NTU for non-trout lakes [17].

The conductivity of the water before treatment with *Citrus sinensis seed* extract was found to be 45±6.00µScm^{-1}. Treatment of the water with 1g/L, 3g/L and 5g/L of the seed extract increased the conductivity to 121±8.00, 161±19.70 and 209±21.52µScm^{-1} respectively. This conductivity significantly increases ($p<0.05$) with the increase in concentration of the seed extract. Conductivity is a measure of water's capability to pass electrical flow [18]. This ability is directly related to the concentration of ions in the water. These conductive ions come from dissolved salts and inorganic materials such as alkalis, chlorides, sulfides and carbonate compounds [19].

It was suggested that a sudden increase or decrease in conductivity in a body of water can indicate pollution [20], which could results from agricultural runoff or a sewage leak due to the additional chloride, phosphate and nitrate ions [18]. When water temperature increases, so will conductivity [19]. For every 1°C increase, conductivity values can increase 2-4%. Tap water and portable water in the US were observed to have conductivity of 50-800 and 30-1500 respectively [17].

Our study revealed the pH of tap water source for Kano state to be 8.90±0.20. Following treatment, the pH was observed to decrease significantly ($p<0.05$) to 7.50±0.44, 6.53±0.03 and 6.25±0.25 at 1g/L, 3g/L and 5g/L seed extract concentrations respectively. The recommended acceptable range of pH for drinking water specified by [15] is between 6.0 and 8.0. A rise in pH observed from a water body could be attributed to carbonate-rich soils (carbonates and bicarbonates) such as limestone [12]. pH decrease may also be caused by sewage outflow and aerobic respiration [18].

The alkalinity of water also plays an important role in daily pH levels. The process of photosynthesis by algae and plants uses hydrogen, thus increasing pH levels [21]. Likewise, respiration and decomposition can lower pH levels. Most bodies of water are able to buffer these changes due to their alkalinity, so small or localized fluctuations are quickly modified and may be difficult to detect [21]. pH can also affect the solubility and toxicity of chemicals and heavy metals in the water [22]. Humans have a higher tolerance for pH levels (drinkable levels range from 4.0-11.0 with minimal gastrointestinal irritation), there are still concerns [23]. pH values greater than 11 can cause skin and eye irritations, as does a pH below 4.0. A pH value below 2.5 will cause irreversible damage to skin and organ linings in aquatic animals [23]. Lower pH levels increase the risk of mobilized toxic metals that can be absorbed, even by humans, and levels above 8.0 cannot be effectively disinfected with chlorine, causing other indirect risks [23]. Additionally, pH levels outside of 6.5-9.5 can damage and corrode pipes and other systems, further increasing heavy metal toxicity [17].

Temperature of the tap water source was observed to be 27.6±3.70 ^{0}C. After treatment with 1g/L, 3g/L and 5g/L, it was found to increase to 28.7±2.20, 28.8±2.05 and 28.7±1.20 ^{0}C respectively. Temperature, being an important factor to consider when assessing water quality influences several other parameters and can alter the physical and chemical properties of water [24]. It can also affect the metabolic rates and biological activity of aquatic organisms [25]. In addition to its effects on aquatic organisms, high water temperatures can increase the solubility and thus toxicity of certain compounds [26]. These elements include heavy metals such as cadmium, zinc and lead as well as compounds like ammonia [27]. Temperature affects conductivity through ionic concentration; salts are more soluble at higher temperatures [28]. However, temperature before and after treatment with the *C. sinensis* extract are within the range of 27-30ºC [15].

Total dissolve solids of the tap water source from our study was observed to be 30.00±2.30mg/l, following treatment with various concentrations of seed extracts at 1g/L, 3g/L and 5g/L, TDS was observed to increased significantly ($p<0.05$) to 100.00±12.40, 130.00±13.50 and 170.00±6.40 ppm respectively. TDS is made up of inorganic salts, as well as a small amount of organic matter [29]. Common inorganic salts that can be found in water include calcium, magnesium, potassium and sodium, which are all cations, and carbonates, nitrates, bicarbonates, chlorides and sulfates, which are all anions [30]. TDS can also affect water taste, and often indicates a high alkalinity or hardness [31]. High concentration of dissolved solids is usually not a health hazard [32].]Regulations protect water which has less than 10,000 milligrams per litre (mg/l) total dissolved solids. To put this value into perspective, most drinking water averages between 200 and 300 milligrams per liter total dissolved solids and water with TDS greater than 500 milligrams per liter is not recommended for human consumption [33.

Conclusion and Recommendations

Citrus sinensis seeds extract demonstrated a promising potential in the treatment of tap water source by its combined significant effect of reducing the turbidity and pH as well as increasing the conductivity and total dissolved solids. It could therefore be considered as a cheaper, safer and alternative coagulant/flocculant to other chemical agents.

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