International Journal of Environmental Bioremediation & Biodegradation, 2024, Vol. 12, No. 1, 8-13
Available online at http://pubs.sciepub.com/ijebb/12/1/2
Published by Science and Education Publishing
DOI:10.12691/ijebb-12-1-2

Drinking Water Potabilization with *Moringa oleifera* Seeds in Some Rural Regions from Niger

Bokoye Yaou[1], Malam Mani Oumarou Tidjani[1,*], Moussa Massaoudou[2], Souley Sahailou[3], Ibrah Landi Ali[1]

[1]Département de Chimie, Faculté des Sciences et Techniques, Université Dan Dicko Dankoulodo de Maradi, Niger
[2]Département de Génie Rural, Eaux & Forêts, Faculté d'Agronomie et des Sciences de l'Environnement, Université Dan Dicko Dankoulodo de Maradi, Niger
[3]Département de Biologie, Faculté des Sciences et Techniques Université Dan Dicko Dankoulodo de Maradi, Niger
*Corresponding author: tidjani.oumarou@uddm.edu.ne

Received October 19, 2024; Revised November 21, 2024; Accepted November 28, 2024

Abstract Water is the most vital raw material in the 21st century. This work falls within the framework of the Care's Initiative for Water and sanitation in rural areas. The crushed seeds of *Moringa oleifera* were powdered, added to a given quantity of water to have a stock solution. This solution was vigorously pouring while stirring quickly to the water to be treated for 30-60 seconds. Then a slower and regular agitation is necessary for 2 to 5 minutes. This water was left to stand in the bucket, without moving it, for 1.5 to 2 hours. Before treatment the physicochemical and bacteriological analysis show that the water samples were not within the range of drinking water potability standards according to Niger and WHO standard except pH values which is in general within the range $6.5 < pH < 8$. But the results of the treatment revealed that all the samples did not display values outside the standards for the parameters considered in physicochemical analysis except lead contained although it has drastically dropped. The bacteriological analysis of the samples treated with *M. oleifera* seeds, show in general that for the case of *Escherichia coli* and *Salmonella* spp, everything is negative. But for Coliforms, all values without exception suffered a drastic drop. Finally, the use of *M. oleifera* seeds use if carefully done with optimizing some parameters will reduce or even eliminate the risk of contamination.

Keywords: *water, water-purification, Moringa oleifera, physico-chemical analysis, biological analysis*

Cite This Article: Bokoye Yaou, Malam Mani Oumarou Tidjani, Moussa Massaoudou, Souley Sahailou, and Ibrah Landi Ali, "Drinking Water Potabilization with *Moringa oleifera* Seeds in Some Rural Regions from Niger." *International Journal of Environmental Bioremediation & Biodegradation*, vol. 12, no. 1 (2024): 8-13. doi: 10.12691/ijebb-12-1-2.

1. Introduction

Water is a vital resource, but only 3% of water on our planet is fresh [1]. Of these reserves just 10% can be exploited economically. It is the most vital raw material in the 21st century [2]. According to [3], supply of adequate clean water to communities is a problem worldwide, especially in developing countries where rural population depends on water from rivers, dams and streams for domestic use which may contain pathogens and toxic materials. Drinking such contaminated water causes diseases such diarrhoea, cholera, dysentery and typhoid leading to severe health problems in the community. Water is used for several purposes by humans, but the level of purity of the water being consumed is very crucial since it has a direct effect on health. More than half of all illnesses and deaths among children are caused by germs, which get into the mouth via water and food [4]. The World Health Organization has estimated that up to 80% of all disease and sickness in the world is caused by inadequate sanitation, polluted water or unavailability of water [5].

It is estimated that 1.1 billion people lack accesses to clean drinking water and there is a water shortage in already 30 countries [2,3,4,5,6]. The access to safe and clean drinking water is a major concern throughout the world. Surface water has become the most common source for raw water, when large quantities of groundwater often are inaccessible, and as surface water requires more treatment, simple, cheap and efficient process methods are necessary [7]. Surface water from rivers, streams and ponds are the most common sources of raw water, but are usually of low quality [8,9]

Thus, many coagulants are widely used in conventional water-treatment process for turbidity removal during potable water production [10,11]. But conventional methods such as chemical precipitation and filtration, disinfection, softening, pH regulation, oxidation and reduction, electrochemical treatment, reverse osmosis and ion exchange are using to improve water quality, are economically non-viable due to high cost of chemicals, plant maintenance and requirement for expertise [8,12,13]. Also, the low-cost synthetic coagulants of aluminum, ferric salts and soda ash widely used for water treatment, but the safety of these substances and their efficiency is increasingly becoming questionable due to health-related issues such as Alzheimer's disease [14,15]. Earlier research findings [16,17,18]. showed that the chemicals used for water purification can cause serious health hazards if an error occurs in their administration during the treatment process. It is in this context that this work falls within the framework of treatment of drinking water with local available products: *Moringa oleifera seeds*.

In fact, in a report published by FAD [19], the level of access to drinking water supply and sanitation services in Niger is among the lowest in Africa. In 2006, the rates of access to drinking water and sanitation in rural areas stand at 59% and 5% respectively. This situation has a very detrimental impact on the health of rural populations and could jeopardize progress economies of this country where approximately 78% of the population lives in rural areas. Indeed, the waterborne diseases and those related to poor hygiene and sanitation rank first in terms of morbidity and mortality in Niger and the knowledge by the population of the factors favoring these diseases remains uncertain. To contribute to the satisfaction of water and sanitation infrastructure needs for thousands of people directly concerned by drinking water, the actions are envisaged through potabilization of Drinking water with Moringa oleifera seeds in the working field of MAMAN LUMIERE III project concerning rural communes of: Dakoussa, Gafati, Albarkaram, Droum and Dogo in Zinder state. The main objective of this study is to conduct a research action on the purification of drinking water with local *Moringa Oleifera* seeds product, with specifically characterization of physico-chemicals and bacteriological properties of drinking water before and after treatment.

2. Materials and Methodologies

2.1. Preparation of Moringa Powder

The crushed seed mixture can be prepared both from the seeds and from the pressed residues (cakes) obtained after extracting the oil from the seeds.

For powder preparation Without oil extraction the 3 steps of are:

The pods containing the seeds should become mature by drying naturally on the tree until they are brown in color, Once the pods have been harvested, the seeds are removed, then shelled (the wings and the husk around the kernel are removed), only the white or yellowish seeds without signs of softening, discoloration or extreme dryness are used.

The seed (kernel) is crushed and sieved using 0.8 mm mesh sieves or equivalent. The traditional pestle/mortar technique used to make maize flour was considered acceptable for grinding M. oleifera seeds. For more profitability and taking into account the socio-economic context of households, cake is used, which is the material obtained after oil extraction.

If the powder preparation is after oil extraction, the four steps are as follow:

Shell the seeds,

Heat these seeds (roasting) to a temperature of 80°C so as not to denature them,

Crush (grind) in the mill to get the paste,

Mix the dough with a little hot water while kneading,

After extracting the oil, sun-dry the residue for two (2) days. Then, pound it or grind it in a mill to obtain a powder [18].

Figure 1. Powder of *M. oleifera* seeds

2.2. Water purification process

The fine powder collected is mixed with clean water to form a paste. To treat 20 liters of water, produce a paste with 2 grams (2 tablespoons) of seed powder, which corresponds to approximately 20 ground almonds (one per liter) when the seeds are used without oil extraction.

But if it is the cake, we use a glass of powdered tea for 20 liters of more or less dirty water.

If the water is slightly cloudy, only one almond can be used for two liters. Experience will determine the optimum dosage.

Dilute the paste in a cup of clean water (from a sealed bottle) and stir the solution vigorously for 1 minute to react the chemical elements of the powder and promote the extraction of the flocculant. 2% stock solutions are the most effective, which means that the two grams of powder will need to be diluted in 100 grams of water;

Remove insoluble material by filtration through muslin cloth, fine mesh mosquito net or nylon or cotton cloth (10µm pore diameter). The filtered, milky-looking liquid is the stock solution. It must be lightly shaken before use. In hot climates, this suspension cannot be stored and must therefore be prepared daily.

Stir the water to be treated quickly while vigorously pouring the stock solution. Rapid agitation should be maintained for 30-60 seconds.

Then a slower and regular agitation is necessary for 2 to 5 minutes. For regularity, a song with two-syllable words can be used, with one whole word corresponding to one full rotation.

Leave the water to stand in the bucket, without moving it, for 1.5 to 2 hours;

When the solid material is decanted to the bottom of the bucket, clean water can then be recovered by checking the turbidity with the naked eye.

It can be noted that This technology is only valid for cloudy water; it is not used to treat borehole water.

2.3. Analyzes of Purified Water

The choice of sites was made in collaboration with the project agents. A list of 9 villages was retained according to the sources of drinking water (Table 1).

Table 1. List of villages according to the water source to be analyzed and the municipality

N°	Date	Commune	Site's codes	Sampling site	Type of water source	water Sampling (liter)
1	25/12/2021	Dakoussa	KOI	Koutarou Ousseini	Well	1L
2	25/12/2021	Dakoussa	YAN	Yachin Aman	Well	6L
3	25/12/2021	Albarkaram	MRW	Mai-Rouwa	Absent	NA
4	25/12/2021	Gafati	TKB	Takassaba	Dam Kassama	6L
5	25/12/2021	Gafati	DKM	Dakalmari		
6	25/12/2021	Gafati	BRS	Dam source	Dam source	1L
7	26/12/2021	Droum	ZLK	Zangon Laka	Well	6L
8	26/12/2021	Droum	IDN	Imdan	Well	1L
9	26/12/2021	Dogo	AWS	Angouwal Salla	Well	6L
10	26/12/2021	Dogo	CFA	Chafaoua	Well	6L

Table 2. Water physico-chimicals analysis before treatment

Parameters	CFA	TKB	YAN	AWS	ZLK	Niger limits
PH	7.27	7.41	6.95	7.40	6.55	6,5 à 8,5
Temp©	7.27	20.0	22.0	22.5	21.5	25°C
Color	Partly cloudy	Partly cloudy	Cloudy	Cloudy	Cloudy	Colorless
Odour	Odorless	Odorless	Odorless	Odorless	Odorless	Acceptable
Taste	Tasteless	Tasteless	Soily taste	Soily taste	Tasteless	Acceptable
Turbidity (NTU)	41	100	64	144	130	≤5 UTN
EC(μs/cm)	0.03	0.14	1.86	0.06	0.16	<1200μs/cm
Hardness(mg/l)	34.0	86.3	51.1	114.2	102.6	200 mg/L (WHO)
Phosphate(mg/l)	0.18	0.64	0.29	1.71	1.01	5mg/L(UE)
Nitrate (ppm)	1.655	1.533	2.088	2.06	1.802	45 ppm
TDS(mg/l)	10.01	3.33	3.30	13.3	3.30	500mg/L
TSS(mg/l)	0.7	0.3	0.7	1.0	0.8	
DO (ppm)	2.87	8.56	4.59	5.88	7.44	
BOD (ppm)	0.92	5.30	1.94	1.96	3.10	10mg/L(UE)
Lead (Pb)(ppm)	2.89	3.86	3.91	2.58	3.96	0,01

KOI: Kountarou Ousseini ; YAN: Yachin Aman ; MRW: Mairouwa ; BRS: Barrage source ; ZLK: Zangon Laka ;
DKM: Dakalmari ; TKB: Takatsaba ; AWS: Angouwal Salla ; CFA: Chafaoua ; IMD: Imdan
UTN: Unité de turbidité néphelométrique ; ppm: parti par million ; mg /L: milligramme par litre

2.1.1. Sampling conditions

1° Water sampling for bacteriological analysis:

The essential conditions to be respected for the sampling are first of all the respect of the rules of asepsis and the non-modification of the flora during the sampling and the transport of the samples.

The manipulations carried out during the collection must in no case be the cause of contamination, hence: the need to use sterile instruments and to work in sterile conditions.

Thus, the samples taken are kept in the cool-box at a temperature between 2-8°C

During our field study, we took 8 water samples.

2° Water sampling for physico-chemical analyses:

The collection of samples for physico-chemical analyzes is of great importance since the results directly reflect the physical and chemical characteristics of the water sampled. Water samples must be taken in clean containers rinsed several times with the water to be analyzed and then closed tightly without leaving any air bubbles in the bottle.

2.1.2. Physico-chemical Water Analysis Methods

Physico-chemical analyzes were done using APHA (2017) standard methods [20] and are essentially limited to the measurement of turbidity, electrical conductivity, color, odor, temperature, total suspended solid (TSS), total dissolved solid (TDS), dissolved oxygen (DO), biochemical oxygen demand (BOD), pH, hardness, Nitrate ions contained, and heavy metals such as lead (Pb)

2.1.3. Bacteriological Analysis

The bacteriological analysis of water will identify the rate of contamination by bacteria and which makes it unfit for consumption. The identification of total coliforms, Salmonella spp and *Escherichia coli* follows a scientific method (IDEXX Colilert Quanti-tray 2000) in the laboratory, from a sample of this water.

3. Results and Discussion

3.1. Physico-chemical Characteristics of Water Before Treatment

The result of physico-chemical and bacteriological analysis before treatment are given in the Table 2 and 3 below.

In general, water from wells and dams have pH values within the range of drinking water potability standards according to Niger and WHO standards 6.5 < pH < 8.5

except for the case of Imdan well water (a well whose depth is about 1.5 meters) whose pH equal to 6.20 is lower than the normal range [21]. This pH value expresses a slightly high level of acidity. The pH value found at the level of Imdan wells is close to that of the well waters (4m deep) of Zangon Laka and this proves an interconnection between these two wells which belong to the same aquifer and which are less than 500 m apart from them.

Table 3. Results of bacteriological analyzes before water treatment

Samples ID	Escherichia coli	Salmonella spp.	Coliforms (MPN/100ml)
BRS	Negative	Positive	93
CFA	Positive	Positive	21
KOI	Positive	Positive	75
TKB	Positive	Positive	9
IMD	Positive	Positive	15
YAN	Positive	Positive	1100
AWS	Positive	Positive	43
ZLK	Positive	Positive	460
Niger limits/WHO	0/100mL	0/100mL	0/100mL

On the other hand, the lead content of all the samples, the turbidity and the color are all higher than the standards of Niger and the WHO. The well waters of Yachin Aman, Imdan, Zangon Laka and Angouawl Salla all have a salty taste.

Consumed by a population of more than 2000 inhabitants, the water from the gutters used by the inhabitants of Takatsaba and Dakalmari which comes from the Kassama dam has physico-chemical characteristics which are somewhat similar to the source of the same name. Like the source, the measured values for turbidity, lead are all above normal. The pH, temperature and turbidity of the water in the gutters are also lower than that of the source. On the other hand, the lead content, the electrical conductivity and the total hardness are higher there.

3.2. Bacteriological Characteristics of Water Before Treatment

These bacteriological analysis results show that apart from the water from the dam in the case of Escherichia coli, all the water collected is contaminated. As a result, all these populations face risks related to these Enterobacteriaceae which will not be without harmful consequences (such as gastroenteritis diseases) on the health of the populations and especially women and children who are the most vulnerable layers. These contamination with Escherichia coli has maintained as Microbiological Quality Water Indicator in several studies [22].

3.3. Physico-chemical Characteristics of Water After Treatment

The results of physico-chemical analysis of samples treated with M. oleifera seeds show a considerable drop in lead content in particular the adsorbent potential as was indicated in earlier studies [23,24]. Apart from the lead content, these results of the analyzes show that on the physico-chemical level, the waters treated with the grains of M. oleifera do not display values outside the standards for the parameters considered in the context of this work. However, the electrical conductivity values, although still within acceptable limits, increased for each sample.

These appreciable results obtained show us the effectiveness of *M. oleifera* seeds for the potabilization of drinking water. This related activity of water purification/potabilization in the community of intervention of the project based on locally available products will undoubtedly contribute to the achievement of one of the specific objectives of Maman Lumière III which is the substantial and sustainable reduction of malnutrition of children under 2 and women aged 15-49 from poor households in the Zinder region by December 2023.

3.4. Bacteriological Characteristics of Water After Treatment

The results of the bacteriological analyzes of the samples treated with *M. oleifera* seeds, as indicated in Table 5 below, show *Escherichia coli* and *Salmonella spp*, are completely eliminated except for the water in the well of Yachin Aman where the result is positive. In this case, other analyzes in particular, an antibiogram must be carried out to better understand the behavior of this strain. In the case of *Coliforms*, even if these germs have not been completely eliminated the values found show that they have been drastically reduced all values without exception suffered a drastic drop. It should be noted that the use *of M. oleifera* seeds or any other technique is not capable of remove 100% of the bacteria present in the water, but this use if carefully done will reduce or even eliminate the risk of contamination. These results corroborate those of Ayegba [25] .

In general, the purification / purification of water using M. oleifera seeds is a method that has proven to be effective and that will allow people in rural areas to better improve their living conditions.

Table 4. Results of water physicochemical analysis after treatment

Parameters	CFA	TKB	YAN	ZLK	AWS	Niger limits
PH	7.25	7.05	6.85	7.0	6.95	6,5 à 8,5
Temp©	23.0	23.0	23.1	24.0	24.0	25°C
Color	Colorless	Colorless	Colorless	Colorless	Colorless	Colorless
Odour	Odorless	Odorless	Odorless	Odorless	Odorless	Acceptable
Taste	Tasteless	Tasteless	Tasteless	Tasteless	Tasteless	Acceptable
Turbidity (NTU)	Less than 5	Less than 5	Less than 5	Less than 5	Less than 5	≤ 5 UTN
EC(µs/cm)	1.26	2.7	37.4	2.66	1.66	<1200µs/cm
Hardness(mg/l)	9.01	6.21	9.51	6.23	4.21	200 mg/L (OMS)

Phosphate(mg/l)	0.12	0.31	0.28	0.59	0.16	5mg/L(UE)
Nitrate (ppm)	0.64	0.81	0.92	0.45		45
TDS(mg/l)	0.001	0.00	0.03	0.00	0.00	500mg/L
TSS(mg/l)	0.03	0.07	0.42	0.09	0.06	
DO (ppm)	1.41	0.93	1.34	3.41	2.41	
BOD (ppm)	0.16	1.32	0.42	0.31	0.53	10mg/L(UE)
Lead (Pb)(ppm)	0.027	0.039	0.311	0.032	0.051	0,01

Table 5. Results of water bacteriological analysis after treatment

Samples ID	*Escherichia coli*	*Salmonella spp.*	*Coliforms (*MPN/100ml)
CFA	Negative	Negative	5
TKB	Negative	Negative	6
YAN 2	Negative	Positive	6
AWS	Negative	Negative	39
ZLK	Negative	Negative	2
Niger limits / WHO	0/100mL	0/100mL	0/100mL

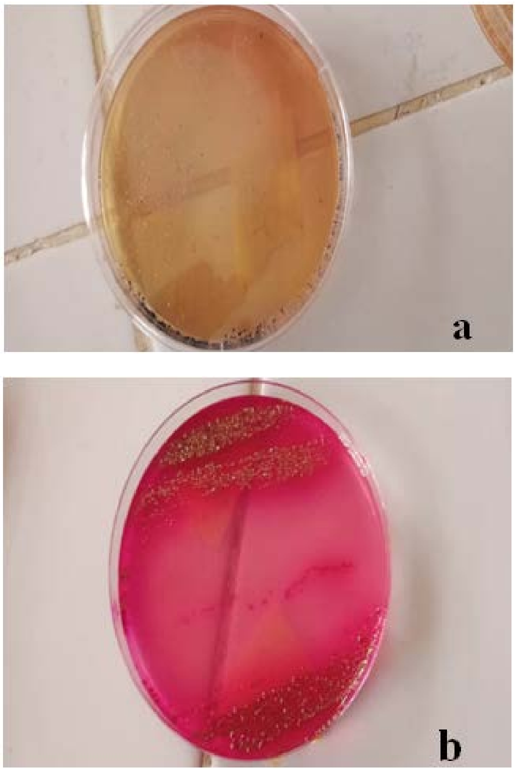

Figure 2. a) Salmonella spp colonies on nutrient agar b) colonies of Escherichia coli on nutrient agar

4. Conclusion and Recommendations

The work undertaken as part of this project is a contribution to the study of water quality in the intervention area of the Maman Lumière III project in the Zinder region (Niger). The results of the analyzes enabled to realize that the water at the sites visited is not fit for consumption. However, the process consisting in using the seeds of M. oleifera in the potabilization of this water shows a clear improvement for obtaining water that is cleaner for consumption given that no method based on local products guarantees clean drinking water. Finally, these results allowed to suggest that an antibiogram (ATBG) of the Salmonella spp strain isolated at Yachin Aman must be performed and An awareness campaign on the drinking water purification procedure at the sites used in the study should be undertaken

ACKNOWLEDGEMENTS

This manuscript is made possible by the financial support of the Care International through **Maman Lumiere III project** and materiel support of Chemestry department and Biology department from Faculty of Sciences and Techniques of **Dan Dicko Dankoulodo University** of Maradi (Niger)

References

[1] Musie, W. and Gonfa, G., 2023. Fresh water resource, scarcity, water salinity challenges and possible remedies: A review. *Heliyon*. Tariq, A. and Mushtaq, A., 2023. Untreated wastewater reasons and causes: a review of most affected areas and cities. *Int. J. Chem. Biochem. Sci*, *23*(1), pp.121-143.

[2] Narender, B.R., Akshitha, K., Prashanth, A., Reddy, Y.S. and Saketh, A., 2019. Treatment of water with Moringa Oleifera as a coagulant. *World J. of Pharmacy and Pharmaceutical Science*, *8*(7), pp.996-1016.

[3] Varkey, Alakaparampil Joseph. "Purification of river water using Moringa Oleifera seed and copper for point-of-use household application." *Scientific African* 8 (2020): e00364.

[4] Tariq, Aqil, Shoaib Ali, Iqra Basit, Ahsan Jamil, Nizom Farmonov, Behnam Khorrami, Muhammad Mohsin Khan et al. "Terrestrial and groundwater storage characteristics and their quantification in the Chitral (Pakistan) and Kabul (Afghanistan) river basins using GRACE/GRACE-FO satellite data." *Groundwater for Sustainable Development* 23 (2023): 100990.

[5] World Health Organization, 2012. Vaccines against influenza WHO position paper—November 2012. *Weekly Epidemiological Record= Relevé épidémiologique hebdomadaire*, *87*(47), pp.461-476.

[6] Mishra, Rakesh Kumar. "Fresh water availability and its global challenge." *British Journal of Multidisciplinary and Advanced Studies* 4, no. 3 (2023): 1-78. Rasheed, Farouk Abdullah, Karwan

[7] Brindha, K. and Schneider, M., 2019. Impact of urbanization on groundwater quality. *GIS and geostatistical techniques for groundwater science, 2019*, pp.179-196.

[8] Karimidastenaei, Z., Avellán, T., Sadegh, M., Kløve, B. and Haghighi, A.T., 2022. Unconventional water resources: Global opportunities and challenges. *Science of the Total Environment*, *827*, p.154429.

[9] Magaji, U.F., Sahabi, D.M., Abubakar, M.K. and Muhammad, A.B., 2015. Biocoagulation activity of Moringa oleifera seeds for water treatment. *IJES*, *4*, pp.19-26.

[10] Bwire, Godfrey, David A. Sack, Atek Kagirita, Tonny Obala, Amanda K. Debes, Malathi Ram, Henry Komakech, Christine

Marie George, and Christopher Garimoi Orach. "The quality of drinking and domestic water from the surface water sources (lakes, rivers, irrigation canals and ponds) and springs in cholera prone communities of Uganda: an analysis of vital physicochemical parameters." *BMC public health* 20 (2020): 1-18.

[11] Mogbo, Onyebuchi N., Michael B. Iorwua, Egoro C. Duweni, and Michael T. Tiza. "A study on the efficacy of bio-coagulants for turbid and waste water treatment." *J. Crit. Rev* 7 (2020): 1307-1315.

[12] Benalia, Abderrezzaq, Kerroum Derbal, Zahra Amrouci, Ouiem Baatache, Amel Khalfaoui, and Antonio Pizzi. "Application of Plant-Based Coagulants and Their Mechanisms in Water Treatment: A Review." *Journal of Renewable Materials* 12, no. 4 (2024).

[13] Korak, J.A., Mungan, A.L. and Watts, L.T., 2023. Critical review of waste brine management strategies for drinking water treatment using strong base ion exchange. *Journal of Hazardous Materials*, *441*, p.129473.

[14] Jin, H., Yu, Y. and Chen, X., 2024. Electrochemical precipitation for water and wastewater treatment. *Process Safety and Environmental Protection*.

[15] Teh, C.Y., Budiman, P.M., Shak, K.P.Y. and Wu, T.Y., 2016. Recent advancement of coagulation–flocculation and its application in wastewater treatment. *Industrial & Engineering Chemistry Research*, *55*(16), pp.4363-4389.

[16] Muniraj, S., Muthunarayanan, V., Venkataraman, S., Sunitha, T.G. and Thamaraiselvi, C., 2023. Drinking water treatment with natural coagulants—a promising alternative for sustainable water usage. Resource Recovery in Drinking Water Treatment, pp.107-127.

[17] Khokhlov, A.N., 2023. Why freshwater hydra does not get Alzheimer’s Disease. Moscow University Biological Sciences Bulletin, 78(3), pp.198-204.

[18] Miller, Morgan R., Yee Fun Lee, and Ksenia V. Kastanenka. "Calcium sensor Yellow Cameleon 3.6 as a tool to support the calcium hypothesis of Alzheimer's disease." *Alzheimer's & Dementia* 19, no. 9 (2023): 4196-4203.

[19] **FAD (2009):** Projet d’approvisionnement en eau potable et d’assainissement en milieu rural dans les regions de maradi, tahoua et tillaberi

[20] Adekitan, A. A., J. O. Oyewumi, V. O. Dada, B. O. Layi-Adigun, and I. Raheem. "Use of Neem Leaf, Pawpaw Seed and Moringa Seed as Natural Coagulants for Surface Water Treatment." *Journal of Applied Sciences and Environmental Management* 27, no. 7 (2023): 1347-1352.

[21] Ogbonna, P.C., Oparaocha, E.T., Anyanwu, E.C. and Innocent, D.C., 2024. Physico-chemical analysis of hospital water in selected secondary health facilities in Bayelsa state, Nigeria.

[22] Zarić, G., Cocoli, S., Šarčević, D., Vještica, S., Prodanović, R., Puvača, N. and Carić, M., 2023. Escherichia Coli as Microbiological Quality Water Indicator: A High Importance for Human and Animal Health: Microbiological Water Quality. *Journal of the Hellenic Veterinary Medical Society*, *74*(3), pp.6117-6124.

[23] Sané, N., Mbengue, M., Ndoye, S., Stoll, S., Poté, J. and Le Coustumer, P., 2024. Effect of Moringa oleifera Seeds Powder on Metallic Trace Elements Concentrations in a Wastewater Treatment Plant in Senegal. *International Journal of Environmental Research and Public Health*, *21*(8), p.1031.

[24] Benettayeb, A. and Haddou, B., 2023. New biosorbents based on the seeds, leaves and husks powder of Moringa oleifera for the effective removal of various toxic pollutants. *International Journal of Environmental Analytical Chemistry*, *103*(18), pp.6859-6884.

[25] Ayegba, S., Abdallah, H., Okoye, C., Adamu, B., Maliki, H., Abubakar, Z., Idris, H., Maidawa, G., Musa, F. And Mustapha, F., 2023. Evaluation of The Efficacy of Moringa Oleifera Seed Powder in Purification of Water. *International Journal of Agriculture And Agricultural Technology*.

© The Author(s) 2024. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (http://creativecommons.org/licenses/by/4.0/).