International Journal of Advances in Engineering and Management (IJAEM)
Volume 4, Issue 5 May 2022, pp: 1245-1254 www.ijaem.net ISSN: 2395-5252

Comparative Analysis of Plants-Based Materials as Natural Coagul Ant in Raw Water Treatment

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Submitted: 10-05-2022 Revised: 19-05-2022 Accepted: 22-05-2022

ABSTRACT
Theresearchwascarriedouttocomparethepotentialsandeffectivenessofplant-basedmaterialsascoagulantsinrawwatertreatment.AloeVeraGel,SeedsofMoringa,TamarindandWaterMelonwereusedasnaturalcoagulants,totreatrawwater.Moringaseedspowder,AloeVerageland Tamarindseedspowderand AloeVerageland WaterMelonSeedsPowderwereprepared.Jartestanalysiswascarriedout,usingstiringtimeof30minutesand400rpmthroughouttheexperiment.Settlingtime,pH,turbidityremoval,percentageofcoagulationperformance,TDSandTSSwereanalysed.Settlingtimeof5minutes,pHof7.21,finalturbidityof21coagulationperformanceof95.3%,turbidityremovalof429NTU,TDSof118mg/landTSSof0.08gwererecordedforMoringaseedspowder.Also,4minutes,18NTU,6.93,96%,432NTU,138mg/land0.08gwererecordedusingAloeveragelforsettlingtime,finalturbidity,pH,percentageofcoagulationperformance,turbidityremoval,TDSandTSSrespectively.Also,23minutes,7.31,33NTU,92.5%,417NTU,160mg/land0.32gwererecordedusingTamarindseedspowderforsettlingtime,pH,finalturbidity,percentageofcoagulationperformance,turbidityremoval,TDSandTSSrespectively.And34minutes,6.97,49NTU,91.1%,138NTU,138mg/Land0.23gwererecordedusingwatermelonseedspowderforsettlingtime,pH,finalturbiditypercentageofcoagulationperformance,turbidityremoval,TDSandTSSrespectively.Itwasdiscoveredthatalltheplants-basedmaterials(AloeVera,Moringa,TamarindandWaterMelonseeds)havethepotentialstoeffectivelyserveascoagulantandalsohavethepotentialstoserveasdisinfectantsinrawwatertreatment
Keywords:AloeVeragel,Moringaseeds,Tamarindseeds,WaterMelonSeeds,coagulationperformance,turbidityremoval,SettlingtimeandStiringtime.

I. INTRODUCTION

Waterisoneofthebasicneedsforlivingorganisms(bothplantsandanimals)toliveonEarth.Forhumanbeings,itisnotwaterpersay;butcleanandpureone.Acleanandpurewateristheonewhichdonothaveanydisease-causingpathogensandwhichundergoesproperwatertreatmentprocesses,andthusreadyforconsumption(WHO,2017).Itisvitalforsocietiestohavecleanandpurewater,asshortageofit,causeswaterbornediseases,whicharekillerdiseases(WHO,2017).Accesstosufficientamountofcleanandpurewaterisvitalforhumanhealthandsocioeconomicdevelopment,because70%ofhumanbodyismadeupofwater(Kulinkinaetal..,2016)Thatiswhy,WorldHealthOrganization(WHO,2017),putmuchemphasisoncleanwaterandisalwaysensuringthatpeopleinbothruralandurbanhaveaccesstocleanwater;notonlyWHO,butgovernmentandprivateorganizations.Despitethefactthat70%oftheearthiscoveredwithwater,only3%ofthewaterisclean,pureandsafefordrinking(WHO,2011).Thesestatistics,iswhatmakesprovidingcleanwatertosocietiesbypoliciesmakersadauntingchallenge,becausecurrentlyabout1.1billionpeople(bothruralandurban)arefacingandexperiencingtheproblemofcleanwatershortage(WHO,2011).Thisroughlyaffects27%ofworldpopulationandthushighlightingtherealthreattheproblemiscausing,whichinthelastdecadedescribedas"GlobalWaterCrisis"(CainandGleick,2005)and"GlobalWaterScarcity"(UnitedNation,2013).Failuretoprovidesafedrinkingwaterandadequatesanitationservicestoallpeopleisperhapsthegreatestdevelopmentfailureofthetwentiethcentury(Gleick,2005)

Inorganiccoagulantsreferstometalcoagulantswhicharegenerallybasedonaluminumandiron.Theyareusedinwaterandwastewatertreatment.Duetotheiravailabilityandeffectiveness,theyarethemostusedcoagulant.Theyinclude:AluminumSulphate,Aluminum

Chloride,AluminumChlorohydrate,SodiumAluminate,PolyaluminiumChloride,PolyaluminiumSulphate (Bratby,2016).Ironcoagulantinclude:FerricSulphate ,FerricChloride,FerrousSulphate(Bratby,2016).Hydratedlimeandmagnesiumcarbonateareotherexamples ofmetalcoagulant,notbasedonaluminumandiron.Duetotheireffectivenessandavailability.

Naturalcoagulantsarederivedfromplantsandanimalssourceandaregenerallyregardedasorganicpolymers.Naturalcoagulantsaretoxicfree,biodegradable,cheapandavailable.Itwasreportedthat,over50naturalcoagulantsarebeingreportedforwatertreatment(SaleemandBachman,2019).Naturalcoagulantsgainsadvantageoverchemicalcoagulants,duetovariousreasons .Amongthemisthat,naturalcoagulantsaresaferthanchemicalcoagulants.Byusingchemicalcoagulants,there willbeapossibilityofresiduepresentinthewateraftertreatment,whenconsumed,theresidueofchemicalcoagulantssuchasalumisharmful,bycausingAlzheimer'sdisease(GardeandBuchberger,2017).Ontheotherhand, residueofnaturalcoagulantisnotharmful.Naturalcoagulantsarecheapercomparedtochemicalcoagulants.Thisisbecauseduringtreatment,chemicalcoagulantslike alumneedscoagulantaidtoeffectivelytreathighturbid water,thusmakingitmoreexpensiveanddifficulttobeusedinpoorcountries,whereasnaturalcoagulantscaneasilybeextractedfromvariousplantswasteswhichreducesthecostoftreatment(Antovetal..,2010).However,fornaturalcoagulantstobeusedatcommercialscale,itmustbeabundantandlocallyavailable.Naturalcoagulants havesomedisadvantages,becauseitincreasestheorganicmatterpresent,thusincreasingmicrobialactivity.Naturalcoagulantsneedslongersedimentationandsettling timeandtheremovalefficiencyofbacteriaisnothigh,thusbringingthepossibilitiesofsecondarybacterialgrowth(Awadetal..,2013)

1.1STATEMENTOFPROBLEM

Theusesofinorganicandsyntheticcoagulantsforwater treatmentiscostlyandhavesideeffecttohealthofpeople ,andnoteveryonehaveaccesstothem.Recentstudieshaveindicatedanumberofseriousdrawbackslinkedtotheuseofaluminumsaltssuchas Alzheimer’sdiseaseassociatedwithhighaluminumresidualsintreatedwater,excessivesludgeproductionduringwatertreatmentandconsiderablechangesinwaterchemistryduetoreactions withtheOH$^-$ andalkalinityofwater.Inaddition,theuseofalumsaltsisinappropriateinsomedevelopingcountriesbecauseofthehighcostsofimportedchemicalsandlowavailability ofchemicalcoagulants(Adejumoetal.,2013).Also,monomersofsomesyntheticorganicpolymerssuchasacrylamidehaveneurotoxicityandstrongcarcinogenicpropertiesandbecauseofthis,therehasbeenconsiderableinterestinthedevelopmentofnaturalcoagulantswhicharesafeforhumanhealthandbiodegradable(Ghebremichael,2004).

Ontheotherhand,AloeVera,seedsofMoringa,TamarindandWaterMelonareabundant,cheap,andarealways discarded.Thisalwaysaddstoenvironmentalpollution andtheirunderutilization.

1.2JUSTIFICATION

CleanandPortablewaterisoneofthemajoringredientsusedintheproductionofmostfoods,especially softdrinks.Coagulationprocessisoneofthemainstages fortheproductionofcleanandportablewaterfromsurfacewater(rawwater).AloeVeragel,seedsofMoringa,TamarindandWaterMelonservesascheapest,available, biodegradableandeasiestsourceofnaturalcoagulantsforwatertreatment,especiallyatdomesticlevel.Harnessingthepotentialofthesenaturalproductswillhelpinreducingenvironmentalpollution,whichtheybringandproducingacheapandeffectivecoagulant.Peoplelivinginruralareas,usesnaturalplantmaterialsforhousehold watertreatment,thus,assessingandevaluatingthepotentialsofplantmaterialsasnaturalcoagulantinadvance watertreatmenttechnologywillprovidebetterandsustainableknowledgeforimprovedhouseholdwatertreatmentwhichcanalsobetransferredbacktoruralareas.

1.BROADOBJECTIVES

Thebroadobjectivesofthisresearchistocomparethepotentialsandeffectivenessofplant-basedmaterialsasnaturalcoagulantsinrawwatertreatment

1.4SPECIFICOBJECTIVES

Thespecificobjectivesofthisworkare:
TocarryoutjartestanalysisforAloeVeragel,Moringa, TamarindandWaterMelonseedspowder,andcompare theireffectiveness.
Toanalyzethephysicalparametersofthewaterafterthejartest(pH,turbidityremoval,coagulationperformance ,TDSandrateofsettling).
To analyze the chemical parameters of the water after the jar test (acidity , alkalinity , hardness and chlorides

II. MATERIALS AND METHODS

2.1SourcesofMaterials

TherawwatersamplewascollectedatthebackofZobewatertreatmentplantsamplecollectionpoint.TheseedsoftheMoringawasobtainedfromanearbyirrigationfarmatDutsin-Matown;theAloeVerawasobtainedatthenurserygardeninDutsin-Matown,KatsinaStateNigeria,whilewatermelonseedswasobtainedatDutsin-Mamarket

2.2.1PreparationofAloeVeraGel

ThesamplesofthefreshAloeVera(25–30cm)longwasselectedandcollectedinapolyethylenebag,andtakentothelaboratoryintheZobeWaterTreatmentPlant.TheAloeVerawaswashedthoroughlywithcleanwaterandcutintopiecesusingrazorblade.ThepiecesoftheAloeVerawasthengrindedusingelectricblendingmachine.TheblendwasfilteredtoseparatethegelfromthefiberoftheAloeVera.Thegelwasthenintroducedintothe500mldistilledwaterandstirredwellusingstirrerfor40minutes.Thesolutionwasstrainedthroughasieveof30mm.ThefiltratewascollectedasAloeVeragelandstoredinarefrigerator(Amrutaetal..,2017)

2.2.2PreparationofMoringaSeedsPowder
Theseedsofthemoringawaswashedwithcleanwater,andthendriedusingovenat55degreecelsiusfor4hours.Thedriedseedswillbegrindedusingpestleandmortar,andthepowderedMoringaseedswillbeobtained(SaleemandBuchman,2019)

2.2.3PreparationofWatermelonseedPowder
Thewatermelonfruitswasslicedopenusingacleanstainless-steellaboratoryknifetoobtaintheseed.Theseedswaswashedseverallywithwater,sun-driedforaweek,sortedtoremovebadones,shelledandgroundwithahigh-speedlaboratoryelectricblender,packedinanairtightcontainer.50gofthecrushedseedswaspackedinathimbleandplacedinasoxhletextractionapparatus.300mlofn-Hexanewasusedtoextractoilfromthecrushedseedinthecolumn.Theapparatuswasleftrunningforabout5hrsandstoppedwhentheextractionwascomplete.Thecakewaswashedwithdistilledwatertoremoveresidueofthen-Hexane,driedinanoventillconstantweightandthensieved.Thefinerparticleswasusedasthecoagulant(Ezehetal..,2017)

2.2.4PreparationofTamarindSeedsPowder
Thewholeseedsofthetamarindwaswashedseverallywithwater,sun-driedforaweek,sortedtoremovebadones,shelledandgroundedtoafinepowderusingalaboratorymill.Allthegroundedmaterialswassievedthrough750µmsieveandthefractionwithparticlesizeslessthan750µmwasusedinexperiments.

2.2.5ProcedureforJarTestAnalysis
Thejartestanalysiswascarriedoutbyputtingvariousgrams(1g,2g,3g,4g,5gand6g)ofAloeVeragelinthesixbeakerscontainingtherawwater,whilethespeedofthemachinewasadjustedslowly.AftervaryingthegramsoftheAloeVeragel,thespeedwasincreased.Themixtureofboththerawwaterandthegelwasstirredataspeedof400rpm(revolutionperminute),for30minutes.Thejartestmachinewasthenswitchedoff.ThesameprocedurewasrepeatedforMoringaseedspowder,TamarindseedspowderandWaterMelonSeedsPowderrespectively(APHA,2005).Thefollowingobservationsweremadeduringtheanalysis:
Therateofformationofflocs
Therateofsettlingofflocs
Clarityofthewater
2.2.6DeterminationofpH: Procedureof(APHA,2005)wasused
2.3.2DeterminationofTurbidity: Procedureof(APHA,2005)wasused
2.2.7DeterminationofTDS: Procedureof(APHA2005)wasused
2.2.8DeterminationofTSS: Procedureof(APHA2005)wasused

2.2.9AnalyticalMethods
Theeffectsofthesepowderedseedsandgelascoagulantwasdeterminedbasedontheperformanceofcoagulationactivityandturbidityremoval.Coagulationactivitywasconductedbasedon(Kukicetal..,2010)whileturbidityremovalexpressedinNTU(nephelometricturbidityunit)wasdeterminedusingturbiditymeterHACH2100Q.Equations1and2showsthecalculationsformulastocomputethepercentageofcoagulationperformanceandturbidityremoval.

TurbidityRemoval=InitialTurbidity-FinalTurbidity$Tr=Ti-Tf$..........Equation(1)
WhereTr=TurbidityRemoval
Ti=InitialTurbidity
Tf=FinalTurbidity
CoagulationPerformance(%)=$\frac{Ti-Tf}{Tf}\times 100\%$..............Equation(2)

Table showing the results of Initial parameters of the raw water

S/No	Parameters	InitialValues
1	Odour	Objectionable
2	Colour	20
3	Taste	Unobjectionable
4	MouthFeel	Unobjectionable
5	OverallAcceptability	Objectionable
6	pH	7.02

International Journal of Advances in Engineering and Management (IJAEM)
Volume 4, Issue 5 May 2022, pp: 1245-1254 www.ijaem.net ISSN: 2395-5252

7	Turbidity	450mg/L
8	TDS	550mg/L
9	TSS	2.04g
10	Hardness	19.8mg/L
11	Acidity	8.2mg/L
12	Alkalinity	120mg/L
13	Chloride	40mg/L

Table 1.Results for Aloe Vera Gel

Coagulant Dose (g)	Stirring Time (min)	Rateof Settling (min)	Initial Turbidity (NTU)	Final Turbidity (NTU)	Turbidity Removal (NTU)	Coagulation Performance (%)	pH	TDS (mg/L	TSS (g)
1	30	5	450	25	425	94.4	6.69	180	0.01
2	30	4	450	21	429	95.3	6.72	176	0.01
3	30	4	450	21	429	95.3	6.83	135	0.06
4	30	3	450	17	433	96.2	7.01	117	0.13
5	30	3	450	15	435	96.6	7.10	117	0.16
6	30	2	450	09	441	98.0	7.23	103	0.16

Table2.ResultsforMoringaSeedsPowder

Coagulant Dose (g)	Stirring Time (min)	Rateof Settling (min)	Initial Turbidity (NTU)	Final Turbidity (NTU)	Turbidity Removal (NTU)	Coagulation Performance (%)	pH	TDS (mg/L	TSS (g)
1	30	08	450	27	423	94.0	6.90	134	0.01
2	30	08	450	25	425	94.4	7.01	134	0.01
3	30	06	450	23	427	94.8	7.10	122	0.05
4	30	05	450	20	430	95.5	7.21	107	0.10
5	30	05	450	18	432	96.0	7.25	105	0.15
6	30	03	450	13	437	97.1	7.26	103	0.18

Table3.ResultsforWaterMelonSeedsPowder

Coagulant Dose (g)	Stirring Time (min)	Rateof Settling (min)	Initial Turbidity (NTU)	Final Turbidity (NTU)	Turbidity Removal (NTU)	Coagulation Performance (%)	pH	TDS (mg/L)	TSS (g)
1	30	37	450	42	408	90.6	6.80	140	0.20
2	30	36	450	42	408	90.6	6.82	140	0.21
3	30	36	450	41	409	90.8	6.92	138	0.21
4	30	34	450	39	411	91.3	7.01	138	0.25
5	30	29	450	37	413	91.7	7.05	137	0.26
6	30	29	450	37	413	91.7	7.25	132	0.26

Table4.ResultsforTamarindSeedsPowder

Coagulant Dose (g)	Stirring Time (min)	Rateof Settling (min)	Initial Turbidity (NTU)	Final Turbidity (NTU)	Turbidity Removal (NTU)	Coagulation Performance (%)	pH	TDS (mg/L)	TSS (g)
1	30	25	450	38	412	91.5	6.92	166	0.30

International Journal of Advances in Engineering and Management (IJAEM)
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2	30	25	450	38	412	91.5	7.01	166	0.30
3	30	23	450	37	413	91.7	7.20	162	0.35
4	30	23	450	30	420	93.3	7.22	157	0.32
5	30	20	450	28	422	93.7	7.31	155	0.32
6	30	17	450	28	422	93.7	7.10	155	0.33

Table5.ResultsforChemicalAnalysis(MoringaSeedsPowder)

Coagulant Dose (g)	Acidity Removal (mg/L)	Final Acidity (mg/L)	Alkalinity Removal (mg/L)	Final Alkalinity (mg/L)	Chloride Removal (mg/L)	Final Chloride (mg/L)	Hardness Removal (mg/L)	Final Hardness (mg/L)
1	4	4	65	55	23	17	11.5	8.3
2	4	4	65	55	23	17	11.6	8.2
3	5	3	70	50	24	16	12.4	7.4
4	5	3	70	50	27	13	12.4	7.4
5	5.5	2.5	70	50	27	13	12.5	7.3
6	6	3	70	50	29	11	12.2	7.6

Table6.ResultsforChemicalAnalysis(AloeVeragel)

Coagulant Dose (g)	Acidity Removal (mg/L)	Final Acidity (mg/L)	Alkalinity Removal (mg/L)	Final Alkalinity (mg/L)	Chloride Removal (mg/L)	Final Chloride (mg/L)	Hardness Removal (mg/L)	Final Hardness (mg/L)
1	3.4	4.6	37.0	63.0	19.0	21.0	10.1	9.7
2	3.6	4.4	36.5	63.5	19.0	21.0	10.5	9.3
3	4.1	3.9	60.9	59.1	19.5	20.5	12.7	7.1
4	5.0	3.0	61.5	58.5	19.6	20.4	12.9	6.9
5	5.1	2.9	64.0	56.0	20.2	19.8	12.9	6.9
6	5.2	2.8	64.1	55.9	22.0	18.0	14.2	5.6

Table7.ResultsforChemicalAnalysis(TamarindSeedsPowder)

Coagulant Dose (g)	Acidity Removal (mg/L)	Final Acidity (mg/L)	Alkalinity Removal (mg/L)	Final Alkalinity (mg/L)	Chloride Removal (mg/L)	Final Chloride (mg/L)	Hardness Removal (mg/L)	Final Hardness (mg/L)
1	3.4	4.6	37.0	63.0	19.0	21.0	10.1	9.7
2	3.6	4.4	36.5	63.5	19.0	21.0	10.5	9.3
3	4.1	3.9	60.9	59.1	19.5	20.5	12.7	7.1
4	5.0	3.0	61.5	58.5	19.6	20.4	12.9	6.9
5	5.1	2.9	64.0	56.0	20.2	19.8	12.9	6.9
6	5.2	2.8	64.1	55.9	22.0	18.0	14.2	5.6

Table8.ResultsforChemicalAnalysis(WaterMelonSeedsPowder)

Coagulant Dose (g)	Acidity Removal (mg/L)	Final Acidity (mg/L)	Alkalinity Removal (mg/L)	Final Alkalinity (mg/L)	Chloride Removal (mg/L)	Final Chloride (mg/L)	Hardness Removal (mg/L)	Final Hardness (mg/L)

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1	2.4	5.6	51.7	68.3	13.7	26.3	9.1	10.7
2	2.2	5.8	51.8	68.2	13.8	26.2	9.6	10.2
3	2.2	5.8	52.7	67.3	14.7	25.3	10.5	9.3
4	1.9	6.1	57.1	62.9	16.0	24.0	10.8	9.0
5	1.8	6.2	57.2	62.8	16.4	23.6	11.2	8.6
6	1.8	6.2	58.8	61.2	16.8	23.2	11.3	8.5

III. DISCUSSION OF RESULTS

Table1showedtheresultsforstiringtime,rateofsettling,pH,turbidityremoval,coagulationperformance,TDSandTSSforthejartestanalysiscarriedoutusingMoringaseedspowder.Thevaluesforthesettlingtimerecordedwere8minutes,8minutes,6minutes,5minutes,5minutesand3for1g,2g,3g,4g,5gand6grespectively.TheresultsshowedthatasthemassoftheMoringaseedspowderwasincreased,thesettlingtimedecreased.Thiswasobservedat1g,whichtook8minutestosettledtheflocsparticlesand6gwhichtook3minutes.Thisshowedasignificantdifferenceof5minutes.ThevaluesofthepHrecordedwere:6.69,6.70,6.70,6.83,7.10and7.25for1g,2g,3g,4g,5gand6goftheMoringaseedspowderrespectively. ThevaluesofthepHindicatedthatasthemassofthepowderincreased,thepHincreased.Thiswasobservedat1gwhere6.69wasrecordedand6gwhere7.25wasrecorded.TherewaslesssignificantdifferenceamongthevaluesofthepHrecorded.ThiswasinlinewiththeresultsobtainedbyGhebremichealet al..,(2005)andAloeet al..,(2012),whobothsuggestedthatpHvaluesofthewatersampleswerenotaffectedbyMoringaseedspowder,andthevaluesweremaintainedatalkalinerange..ThepHincreasedwithincreasedinmassofthemoringaseedspowder.Theactionofmoringaseedspowderwasduetothepresenceofsolublecationicproteinsintheseeds.Thissuggestedthatinwater,thebasicaminoacidspresentintheproteinofmoringawillacceptaprotonfromwater,resultinginthereleaseofhydroxylgroupmakingthepHofthewateralkaline.

Thevaluesfortheturbidityrecordedwere:25NTU,21NTU,21NTU,17NTU,15NTUand9NTUfor1g,2g,3g,4g,5gand6grespectively.Thevaluesoftheturbidityremovalwascalculatedbysubtractingthevaluesofthefinalturbidityfromtheinitialturbidityoftherawwaterwhichwas450NTU.Thehighestturbidityremovalvalueobatainedwas441NTUat6gandthelowestrecordedwas425NTUat1g.Thisindicatedthat,increasedinmassofthepowderedseeds,increasedtheturbidityremoval.ThevaluesofthefinalturbidityrecordedwerewithingthestandardvaluesofturbidityfordrinkingwatergivenbyWHO(2006),where25NTUand5NTUweregivenaspermissibleandacceptablevaluesrespectively.Thisfurthershowedthat,Moringaseedscanbeadoptedforwaterpurificationandislikelytoreducecostandalsonothreatorfearofnegativehealthimpact.Also,thepercentageofcoagulationperformancewas98%at6gandlowestvaluevalueofcoagulationperformancewas94.4%at1g.ThisshowedthattheMoringaseedspowderwaseffectiveinremovingturbidityofrawwatersample.

ThevaluesoftheTDSrecordedwere:180mg/l,176mg/l,135mg/l,117mg/l,117mg/l,and103mg/lfor1g,2g,3g,4g,5gand6grespectively.TheresultswereinagreementwithMangaleetal..(2012),whoreportedthatTDSvalueswerereducewhenwaterwastreatedwithMoringaseedspowder.TDSistheamountofbothorganicandinorganicsubstances,whichcandissolvedinawatersample.TheinitialvalueoftheTDSrecordedwas550mg/l.Afterthejartest,at6g,theTDSwas103mg/l.Thehighertheturbidity,thehighertheTDSandviceversa.Also,thevaluesofthetotalsuspendedsolidsobtainedindicatedthat,asthemassofthepowderedseedsincreased,theTSSvaluesincreased.Thiswasobservedat1gwhichhas0.01and6gwhichhas0.16.Asignificantdifferenceof0.15gamongthevaluesoftheTSSwasobatained.Thiswasat6g,therewasstillsomeundissolvedpartilcesinthewater,whichleadtoincreaseinmassoftotalsuspendedsolids.ThiswasalsoinagreementwithReenaandHarsha,(2019)whorecordedadecreasedinTSSvaluesascoagulantdoseincreasedusingPapayaseedspowderandTamarindSeedspowder.

Table2showedtheresultsforrateofsettling,pH,turbidityremoval,performanceofcoagulationperformance,TDSandTSSforthejartestanalysiscarriedoutusingAloeveragel.Thestiringtimewasmaintainedat30minutesforeachcoagulantdose.Thevaluesforthesettlingtimerecordedwere8minutes,8minutes,6minutes,5minutes, 5minutesand3minutesfor1g,2g,3g,4g,5gand6grespectively.Theresultsshowedthatasthemassofthegelwasincreased,thesettlingtimedecreased.Thiswasobservedat1gofthegel,whichtook8minutestosettledtheflocsparticlesand6gofthetook3minutes.Thisshowedasignificantdifferenceof5minutes.ThevaluesofthepHrecordedwere:6.82,6.90,7.00,7.01,7.10and7.22for1g,2g,3g,4g,5gand6goftherespectively.ThevaluesofthepHindicatedthatasthemassoftheincreased,thepHincreasedslightly,whichwasobservedat1gwithand6gwith6.82and7.22respectively.TherewaslesssignificantdifferenceamongthevaluesofthepHrecorded.Italsoshowedthat,thealoeveragelhaslesseffectonpH.ThiswasattributedtotheorganicnatureofthealoeveragelasreportedbyAbderrezzaqetal..,(2021).pHisthedegreeofacidityoralkanilityofsettledwatersample.

Thevaluesfortheturbidityremovalobtainedwere:423NTU,425NTU,427NTU,430NTU,432NTUand437NTUfor1g,2g,3g,4g,5gand6grespectively.Thevalue softheturbidityremovalwascalculatedbysubtractingthevaluesofthefinalturbiditymeasuredfromtheinitialturbidityoftherawwaterwhichwas450NTU.Thehigheststurbidityremovalvalueobatainedwas437NTUat6gandthelowestrecordedwas423NTUat1g.Thisindicatedthat,increasedinAloeveragelincreasedtheturbidityremoval.Also,thehighestcoagulationperformancewas97.1%at6gandpHof7.22andlowestcoagulationperformancewas94%at1gandpHof6.82.ThisshowedthatpHplayedcrucialroleascoagulantareassociatedwithelectricchargesaccordingtoHussainetal..,(2019).TheresultsrecordedwerealsoinagreementwithastudyconductedbyJaouadiet al..,(2020),whichshowedthatAloeveragelwasaneffectivecoagulantinturbidityreductionandBenaliaet al..,(2019)whichprovesturbidityreductionindrinkingwaterby71.6%and84.77%frominitialvalueof13NTU.TheeffectivenessofAloeveragelascoagulantwasbecauseofthepresenceofcarbonylfunctionandprimaryaromaticaminesandthepresenceofNHgroupinamidesasreportedbyFatombietal..,(2013).Also,thepresenceofGlyco-aloe-modinanthroneandtanninswereresponsibleforthecoagulationpropertysimilartoothernaturalcoagulantsasreportedbyAboneleet al..,(2019).

ThevaluesoftheTDSrecordedwere:133mg/l,133mg/l,122mg/l,105mg/l,105mg/land104mg/lfor1g,2g,3g,4g,5gand6grespectively.TDSistheamountofbothorganicandinorganicsubstances,whichcandissolvedinawatersample.TheinitialvalueoftheTDSfortherawwaterrecordedwas550mg/l.Afterthejartest,theAloeveragelat6g,wasabletoreducedtheinitialTDSof550to104mg/l.Thisshowedthat,highercoagulantdosewouldremovedhigherTDS.TheresultsoftheTDSwereinagreementwithMangaleet al..,(2012),whoreportedadecreaseinTDSvaluesasthecoagulantdoseincreasedusingMoringaseedspowder.Thehighertheturbidity,thehighertheTDSandviceversa.Also,thevaluesofthetotalsuspendedsolidsobtainedindicatedthat,astheAloeveragelincreased,theTSSvaluesinincreased.Thiswasobservedat1gwhichhas0.0gand6gwhichhas0.18g.Asignificantdifferenceof0.17gamongthevaluesoftheTSSobatained.ThiswasduetothepresenceofhighfibrecontentinAloeveragel,whichmightnotdissolvedcompletely,andaddtotheTSSvalue.

Table3showedtheresultsforrateofsettling,pH,turbidityremoval,performanceofcoagulationperformance,TDSandTSSforthejartestanalysiscarriedoutusingTamarindseedspowder.Thevaluesforthesettlingtimerecordedwere45minutes,45minutes,43minutes,43minutes,40minutesand38minutesfor1g,2g,3g,4g,5gand6grespectively.TheresultsshowedthatasthemassoftheTamarindseedspowderwasincreased,thesettlingtimedecreased.Thiswasobservedat1gofthe,whichtook45minutestosettledtheflocsparticlesand6gofthepowdertook38minutes.Thisshowedasignificantdifferenceof7minutes.ThevaluesofthepHrecordedwere:6.92,7.01,7.20,7.20,7.31and7.29for1g,2g,3g,4g,5gand6gofthe respectively.ThevaluesofthepHindicatedthatasthemassofthepowderedseedsincreased,thepHdecreasedslightlytoweaklyalkalinerange,whichwasobservedbasedonthesignificantdifferenceof0.91betweenthevaluesrecorded.Italsoshowedthat,Thisisbecause,theinitialvalueofthepHrecordedfortherawwaterwas7.whichincreasedslightlytowhen1gofthewasadded,thenat2gthepHvaluedecreasedslightlyto,thenlaterdecreasedtoandwhen5gand6gwasapplied.pHisthedegreeofacidityoralkanilityofsettledwatersample.ThisisinagreementwiththeresultsrecordedbyReenaet al..,(2019),whichshowsanincreaseinpHvaluesasdoesoftamarindseedspowderincrease.

Thevaluesfortheturbidityremovalobtainedwere:392NTU,392NTU,403NTU,410NTU,412NTUand412NTUfor1g,2g,3g,4g,5gand6grespectively.Thevaluesoftheturbidityremovalwascalculatedbysubtractingthevaluesofthefinalturbiditymeasuredfromtheinitialturbidityoftherawwaterwhichwas450NTU.Thehigheststurbidityremovalvalueobatainedwas412NTUat5gand6gandthelowestrecordedwas392NTUat1g.Thisindicatedthat,increasedinmassofthetamarindseedspowderincreasedtheturbidityremoval.Also,thepercentageofcoagulationperformancewas91.5%at6gandlowestvalueofcoagulationperformancewas87.1%at1g.ThisshowedthatTamarindseedspowderwaseffectiveinremovingturbidityofrawwatersample.ThisisinagreementwiththeresultsobtainedbyVeenaet al..,(2019),whichshowedanincreaseinturbidityremoval,withincreaseinmassoftamarindseedspowderascoagulant.Thepresenceofwatersolubleproteinswithlowmolecules,amidesandhydroxylgrouparewhatmakesTamarindseedstofunctionasnotonlycoagulant,butflocculantasreportedbyEnricoandBernard(2019).Theactivegroupwithnegativechargesreleasedintothesolution,therebyreactingwithpositiveionsormetalionsinthecolloidalsystem.Thiswouldhelpintheformationofheavierflocsandthusdisruptingthecolloidalsystem..ThepositivechargewouldreactswithhydroxylionsinthesuspensiontoneutralizethepHasreportedbyRamadhani et al..,(2013)

ThevaluesoftheTDSrecordedwere:166mg/l,166mg/l,162mg/l,157mg/l,155mg/land155mg/lfor1g,2g,3g,4g,5gand6grespectively.TDSistheamountofbothorganicandinorganicsubstances,whichcandissolvedinawatersample.TheinitialvalueoftheTDSfortherawbwaterrecordedwas580mg/l.Afterthejartest,,theTDSwasreducedto155mg/l.Thehighertheturbidity,thehighertheTDSandviceversa.Also,thevaluesofthetotalsuspendedsolidsobtainedindicatedthat,astheincreased,theTSSvaluesdecrease.Thiswasobservedat1gwhichhas0.30and6gwhichhas0.33.AsignificantdifferenceofamongthevaluesoftheTSSwasobatained.

International Journal of Advances in Engineering and Management (IJAEM)
Volume 4, Issue 5 May 2022, pp: 1245-1254 www.ijaem.net ISSN: 2395-5252

Table4showedtheresultsforrateofsettling,pH,turbidityremoval,performanceofcoagulationperformance,TDSandTSSforthejartestanalysiscarriedoutusingWatermelonseedspowder.Thevaluesforthesettlingtimerecordedwere37minutes,36minutes,35minutes,35minutes,35minutesand33minutesfor1g,2g,3g,4g,5gand6grespectively.Theresultsshowedthatasthemassofthewatermelonseedspowderwasincreased,thesettlingtimedecreased.Thiswasobservedat1gofthepowdered watermelonseeds,whichtook37minutestosettledtheflocsparticlesand6gwhichtook33minutes.Thisshowedasignificantdifferenceof3minutes.ThevaluesofthepHrecordedwere:6.80,6.82,6.92,7.00,7.05and6.90for1g,2g,3g,4g,5gand6gofthewatermelonseedspowderrespectively.ThevaluesofthepHindicatedthatasthemassofthepowderincreased,thepHdecreasedslightlytoweaklyalkalinerange,whichwasobservedat1gwith6.80and6gwith6.90Therewasslightsignificantdifference amongthevaluesofthepHrecorded.Italsoshowedthat,hasnoeffectonpH.Thisisbecause,theinitialvalueofthepHrecordedfortherawwaterwas,decreasedslightlyto when6gofthepowderwasadded.pHisthedegreeofacidityoralkanilityofsettledwatersamples.ThisisinagreementwiththeresultsrecordedbyEzehandOkeke(2017),whichshowedthatincreaseinwatermelonseedspowder,increasethepHofthewatersample.

Thevaluesfortheturbidityremovalobtainedwere:408 NTU,408NTU,409NTU,411NTU,412NTUand412 NTUfor1g,2g,3g,4g,5gand6grespectively.Thevaluesoftheturbidityremovalwascalculatedbysubtractingthevaluesofthefinalturbiditymeasuredfromtheinitialturbidityoftherawwaterwhichwas450NTU.Thehigheststurbidityremovalvalueobatainedwas412NTUat6gandthelowestrecordedwas408NTUat1g.Thisindicatedthat,increasedindoseofthecoagulant,increasedtheturbidityremoval.Also,thevalueofcoagulationperformancewas91.5%at6gandlowestvalueofcoagulationperformancewas90.6%at1g.Thisshowedthatwaseffectiveinremovingturbidityofrawwatersample.ThisagreedwiththeresultsrecordedbyEzehandOkeke(2017),wherehigherturbidityremovalwasrecordedathigherconcentrationofdoseofthecoagulant.Thepresenceofhighprotein,tanninandmineralcontentsinthewatermelonseedswereresponsibleforthecoagulationpropertiesasreportedbyGwanaetal..,(2014)

ThevaluesoftheTDSrecordedwere:140mg/l,140mg/l,138mg/l,138mg/l,137mg/land132mg/lfor1g,2g,3g,4g,5gand6grespectively.TDSistheamountofbothorganicandinorganicsubstances,whichcandissolvedinawatersample.TheinitialvalueoftheTDSfortherawwaterrecordedwas550mg/l.At6g,theTDSwasreducedto 132mg/lfrom550mg/l.Thehighertheturbidity,thehighertheTDSandviceversa.Also,thevaluesofthetotalsuspendedsolidsobtainedindicatedthat,astheMoringaseedspowderincreased,theTSSvaluesdecrease.Thiswasobservedat1gwhichhas0.20gand6gwhichhas0.26g .Asignificantdifferenceof0.1gamongthevaluesoftheTSSwasobatained.

Table5and6showedthevaluesrecordedforthechemicalanalysisusingMoringaseedspowderandAloeveragel,whichshowedadecreasedinthevaluesasthecoagulantdosewasincreased.ThiswasobservedinMoringaseedspowder,where4mg/Land3mg/Lwererecordedforfinalacidity,55mg/Land50mg/Lforfinalalkalinity,17 mg/Land11mg/Lforfinalchlorideand8.3mg/Land7.6 mg/Lforfinalhardnessat1gand6gofthemoringaseedspowderrespectively.Thehighestsignificantdifferencerecordedwas5mg/Lforfinalalkalinity,andthelowestsignificantdifferencerecordedwas0.7mg/Lforfinalhardness.Also,4.6mg/Land2.8mg/Lwererecordedforfinalacidity,63mg/Land55.9mg/Lforfinalalkalinity,21 mg/Land18mg/Lforfinalchlorideand9.7mg/Land5.6 mg/Lforfinalhardnessat1gand6geachrespectivelyforAloeVeragelcoagulant.Thehighestsignificantdifferenceof7.1mg/Lwasrecordedforalkanilityremovalandthelowestsignificantdifferenceof1.8mg/Lforfinalaciditywasrecorded.ThiswasinagreementwiththeresultsobtainedbyVeenaet al..,(2019)whoreportedthatvaluesoffinalacidity,alkalinityandhardnessdecreasedasMoringaandTamarindseedscoaagulantswereadded.

Table7and8showedtheresultsforchemicalanalysiscarriedoutusingwatermelonseedspowder,showedanincreaseinvaluesforfinalacidity,withincreaseincoagulantdose.Thiswasobservedat1gwhere5.6mg/Lwasrecordedand6gwhere6.2mg/Landasignificantdifferenceof5.6mg/Lwasobservedbetweenthehighestandthelowestvalue.But68.3mg/Land61.2mg/Lwererecordedforfinalalkalinity,26.3mg/Land23.2mg/Lforfinalchlorideand10.7mgand8.5mg/Lforfinalhardness,allrecordedat1gand6gofthecoagulantdoserespectively.Thehighestsignificantdifferenceof2.3mg/Lwasrecordedforfinalhardness.

Thevaluesfortamarindseedspowderrecordedforfinalacidityshowedaslightincreasewithincreasedincoagulantdose,thendecreasedslightly.Thevaluesrecordedwere:3.6mg/L,3.6mg/L,3.8mg/L,3.8mg/L,3.7mg/Land3.7mg/Lfor1g,2g,3g,4g,5gand6grespectively.Also,thevaluesrecordedforfinalhardnessshowedsimilartrendwith7.5mg/Land10.4mg/Lwererecordedat1gand6grespectively.Asignificantdifferenceof2.9mg/Land 0.2mg/Lwererecordedforfinalhardnessandfinalalkalinity.Butthevaluesrecordedforfinalalkalinityandfinalchlorideshowedthatincreaseincoagulantdose,decreasethevaluesrecorded.Thiswasobservedat63mg/Land 61.8mg/Land27mg/Land22.6mg/Lforfinalalkanilityandfinalchloriderespectively.ThisagreeswiththefindingsofVeena et al..,(2019).

IV. CONCLUSION

Thereisagrowinginterestintheuseofnaturalcoagulantsderivedfromplantsmaterials,largelybecaus e,theyarebiodegradableandenvironmentallyfriendly. Thevarietyofplant-basedcoagulantsincludesAloevera,seedsMoringa,TamarindandWaterMelonasdiscussedinthisresearchhaveprovidedpromisingcoagulationactivityandturbidityremovalintreatingrawwaterTherefore,itcanbeconcludedthatallthefourplants-basedmaterialscanremoveturbidityinthewaterandincreasecoagulationperformance,withlesseffectonpH.Butaloeveragelandmoringaseedspowdershowedbestpotentialsandeffectivenessinremovingturbidityandcoagulationperformance,thenTamarindseedspowderandwatermelonseeds.

RECOMMENDATIONS

Thefollowingrecommendationsweremade:

1.Differentplantmaterialshouldbeusedlikeorangeseeds,toinvestigateitspotentialsascoagulantagent.

2.Differentplantsmaterialsshouldbeblendtogethertoseetheirpotentialsandeffectiveness

3.Coagulantssolutionshouldbetestedtoseethiereffectiveness

4.Furtherresearchshouldbemadeaboutnaturalcoagulantsofplant-based materials

5.Also,furtherresearchshouldbecarriedoutonhowtoremovethetastesofthealoeveragelwhichisbitterandwhichmayaffectthetasteofthewater.

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