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The Role of Nanocompositers and Adsorbents in the Turbidity Removal Process

Sumithra T M [1]*, Lokeshappa B[2], Rekha K H[3]
1 PG Student, University BDT College of Engineering and Technology, Davanagere, Karnataka
2 Associate Professor, University BDT College of Engineering and Technology, Davanagere, Karnataka
3 University BDT College of Engineering and Technology, Davanagere, Karnataka
*Corresponding Author: *Sumithra TM*

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ABSTRACT: Turbidity imparts a enormous problem in water treatment. An attempt has been made to evaluate the effectiveness of locally available Orange peel and Channa powder as an adsorbent and nanocomposite for reduction of turbidity. The tests were carried out using the conventional jar test apparatus.The dosing of Orange peel and channa powder as an adsorbent and nanocomposite at various concentrations obtained the reduction of turbidity.The orange peel has the ability to remove turbidity levels up to 76% and Channa has the ability to remove turbidity levels up to 82%. Orange peel Nanocomposite has a turbidity content of up to 83% and Channa Nanocomposite has the ability to remove turbidity levels up to 92%.These results conclude that Nanocomposite was more effective compared to natural adsorbents.Utilisation of locally available natural adsorbents and nanocomposites was found to be suitable, easier, cost effective and environment friendly for water treatment.
KEYWORDS: Adsorbents,Nanocomposites,Synthetic turbid water,Orange peel,Channa seed

I. INTRODUCTION

Water is one of the world's most important resources. All plants and animals need water to survive. water, 2.5% of groundwater is pure water and 98.8% of it is ice and groundwater, less than 0.3% of all freshwater in rivers, lakes and atmospheric air, and groundwater contains internal body fluids and synthetic products [1,2].

Improper management and overuse of water resources affect access to safe drinking water as well safe sanitation especially in rural areas. Cleansing before use. Caring for the environment and humanity is a global challenge, water management and wastewater management are alsopart of it. The surface water is highly affected by seasonal variability in turbidity. There are many technologies available, but coagulation is considered to be superior compared to other methods because of its practicality and ease of construction. Among the common practices of coagulants used in water treatment are lime and alum. But there are other health risks such as Alzheimer's disease and mood disorders etc [3, 4].

Nanotechnology has become one of the most tested technologies of the 21st century. Many types of nanomaterials or nanoparticles are used for water treatment processes. For improved water treatment or therapeutic procedures nanotechnology is popular. Today, nanotechnology is a growing area in each field. Cellulose molecules of at least one Nano scale size, 1-100nm are Nano cellulose, Micro-crystalline cellulose is widely used in cellulose derivatives in cosmetics, food, pharma industry, etc. [5,6] and is an important resource due to its table and binding properties [7,8]. Nanocellulose and its applications receive high attention in industrial and research areas due to its unique properties such as high light, high energy, large surface area, rich hydroxyl conversion systems and natural structures with the use of nanocomposites beneficial due to their quantity, low cost and variety large source of cellulose [9].

II.MATERIALS AND METHODOLOGY

For the purpose of this experimentation, two naturally available adsorbents were used. Below are the list of adsorbents and the details about their source of availability.

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1. Orange peel
2. Channa seed

The selection of the adsorbents is subject to its common availability within the Davangere city and its surroundings. Orange peel were readily available in abundance from the consumer outlets indulging in sale of fresh fruit juices. Channa seeds are brought from local market in the Davangere city.

Preparation of Adsorbents

Orange peel

Orange peel (Citrus x senesis) was treated as per the procedure provided by Maya Shaharom et al., (2019) , The outer peels of the Orange fruit were obtained from the byproduct waste available at fruit juice outlets. The Orange Peels were dried, cleaned thoroughly and soaked for 24 hours in distilled water. The soaked peels were drained and then sun-dried for 2 days. Later on crushed to obtain small particle size powder and passed over 40 or 60 mesh sieve. This was used as the final form of adsorbent within the experimentation.

Fig1 : Adsorbent Prepared by Orange Peel

Channa Seed

Channa Seed treatment was derived from KavyaGurumath et al., (2019)[14]. As per the procedure the Channa was washed three times using distilled water and permitted to dry in the sun for three to four days. The Seeds were then powdered by making crushing and smashing the seeds to obtain small particle size powder and passed over 40 or 60mesh sieve. This was used as the final form of adsorbent within the experimentation.

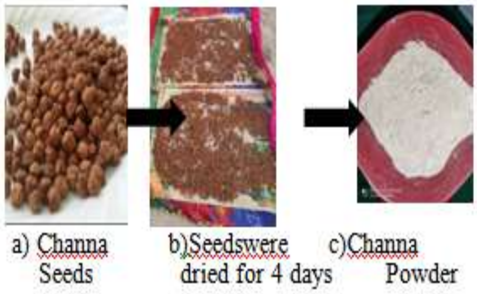

Fig2 : Adsorbent Prepared by Channa seed

Preparation of Nanocompositers

Transfer 50g of each sample to a separate Beaker and apply a 750ml (5%) NaOH solution to each beaker and place these Beakers in a magnetic stirrer for about three hours at 80-100^{0}C. After this, the samples were filtered using a filter paper and pounded continuously with distilled water to completely eradicate the alkali. The filtered samples were removed from the container and stored in the air in an oven at 60^{0}C for about 5-6 hours. After alkaline treatment, a purification process was performed. Different samples were treated with a solution of 500ml hydrogen peroxide (30%) at 50^{0}C for three hours. Also, the emerging fibers were filtered with filter paper and washed continuously with refined water [9, 37, 38].

Fig 3: Preparation of Nanocomposite

Preparation of Synthetic Turbid Water

Prepare kaolin Stock Solution By adding 10 grams of laboratory kaolin grade to 1 Liter Distilled Water. Then strain well using a magnetic stirrer for 30 minutes. Leave it for 24 hours. Pipe 15 ml of the above stock solution and dilute 1 litre add refined water to prepare a 105 sample of warm NTU. Similarly prepare a 6 litre pot test for each concentrated sample of 1 litre 105 NTU.

Fig 4: Preparation of Synthetic Turbid Water

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Methodology

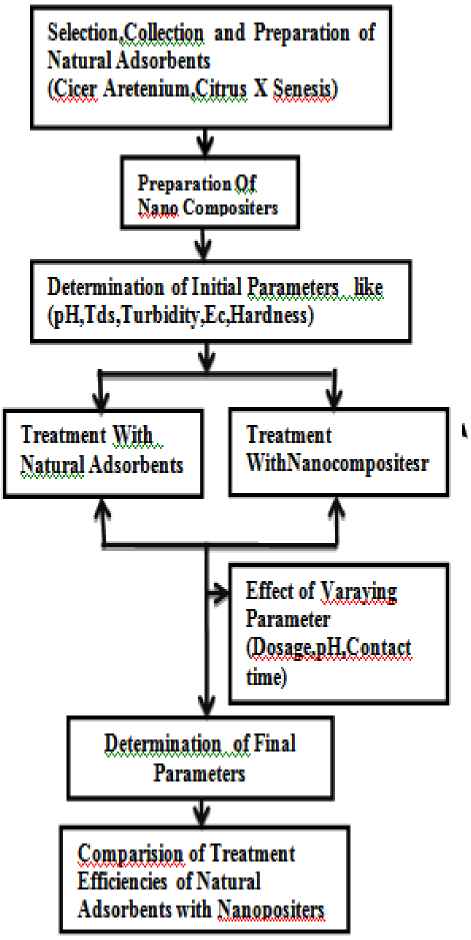

Fig 5: Flow Chart of Methodology

Coagulation Test

Jar test is most widely used experimental methods for coagulation-flocculation. A conventional jar test apparatus was used in experiments to coagulate sample of synthetic turbid water using Orange peel and Channa.It was carried out as a batch test, accommodating a series of five beakers together of 1 liter capacity with five spindle steel paddles. Before operating jar test, sample is mixed homogenously. Then analyze the parameters such as pH, total dissolved solids,turbidity,conductivity and hardness for both Orange peel and channa as adsorbent and nanocompositers by referring APHA book. Then results are plotted on graphs than they are compared.

The Batch Experiment involving rapid mixing, slow mixing and sedimentation. Apparatus consists of five beakers to be agitated simultaneously. 1000 mL of the synthetic turbid water samples is put in to each 5 one-liter beakers and placed under jar test apparatus. The required dose of Orange peel and Channa 1000mL was added simultaneously. The paddles were inserted in jars, apparatus was switched on and whole procedures in jar test were conducted in different rotating speed, which consist of rapid mixing (100 rotations per minute, rpm) for 1 minute and slow mixing (30rpm) for 10 minutes. After agitation has been stopped, suspensions are allowed to settle for 20 minutes. Finally, a sample was withdrawn using a pipette from middle of supernatant for physicochemical measurements, so that effect of coagulant dose on coagulation could been studied. Then, samples are measured for different parameters.

Treatment Procedure Adopted

The experimental studies carried out in two steps,

1. In the first phase a coagulation and flocculation study was performed to obtain the highest coagulant value, from 0.1-0.5 g / 1000mL and the maximum coagulant volume was determined by the efficiency of the extraction of all turbid water parameters.
2. In the second stage the maximum pH was determined. The test is performed with a pHrange of 2-8. The pH values of turbid water are adjusted using 1.0 N for NaOH and 1.0 H_2SO_4.
3. In the third time the fixed contact time, ranging from 10-50min with the appropriate contact time, determines the optimal efficiency of all turbid fluid discharge.

Fig 6: Schematic View of Conventional Jar Test Apparatus

III. RESULTS AND DISCUSSIONS

The experimental setup was built as mentioned below,various samples of synthetic turbid water were tested to determine the removal efficiency of different adsorbents and nanocomposites. To achieve the objectives of the study, the selected parameters mentioned in the methodology, the variation trends are discussed in this section. The results are tabulated and represented through various graphs.

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Characteristics of Synthetically Prepared Turbid Water

Synthetically prepared turbid water was analyzed in Environmental Engineering laboratory, Department of Civil Engineering. The initial characteristics such as pH, TDS, Turbidity, EC, and Total Hardness of synthetically prepared turbid water is given in the table.1.

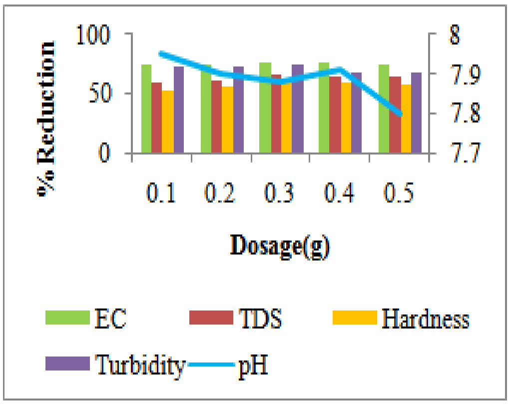
Sl.No	Parameter	Unit	Value
1	pH	-	8.4
2	TDS	mg/L	740
3	Turbidity	NTU	105
4	Conductivity	µs/cm	1400
5	Total hardness	mg/L	300

Table1: Characteristics of synthetically prepared Turbid water used forExperimentation

Performance of Orange peel for Optimum Dosage

Fig 7 shows the performance of Channa as an adsorbent for varying dosage. About 76.21% of conductivity, 66.21% of TDS, 61.66% of hardness, 74.79% of turbidity was removed with dosage of 0.3g of Orange peel, Initial pH was 8.4 and it will be reduced upto 7.88 with the dosage of 0.3g.

Fig 7: Performance of Orange peel as an Adsorbent for Optimum Dosage



Performance of Channa for Optimum Dosage

Fig 8 shows the performance of Channa as an adsorbent for varying dosage. About 79.64% of conductivity, 72.97% of TDS, 64.66% of hardness, 82.41% of turbidity was removed with dosage of 0.3g of Channa,initial pH was 8.4 and it will be reduced up to 7.72 with the dosage of 0.3g.Comparing with these all parameter removal efficiency of turbidity is
high with the Channa

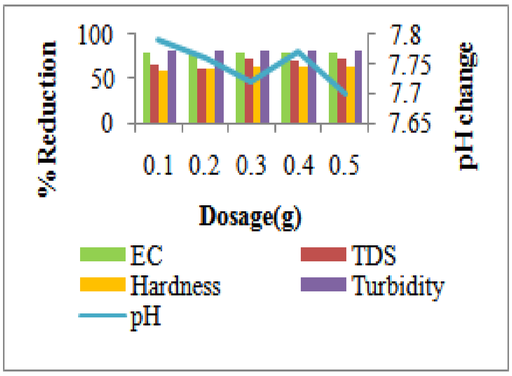


Fig 8: Performance of Channa as an Adsorbent for Optimum Dosage

Performance of Orange peel Nanocomposites for Optimum Dosage

Fig 9 shows the performance of Orange peel as an nanocomposite for varaying dosage. About 83.35% of conductivity, 78.24% of TDS, 66.66% of hradness,83.80% of turbidity was removed with dosage of 0.3g of Orange peel nanocomposite, initial pH was 8.4 and it will be reduced upto 7.43 with the dosage of 0.3g.

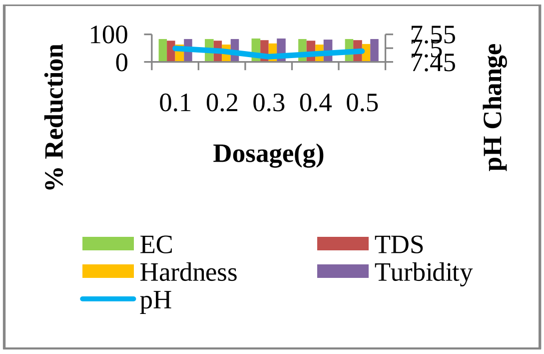


Fig 9: Performance of Orange peel Nanocomposite as an Adsorbent for Optimum Dosage

Performance of ChannaNanocompositers for Optimum Dosage

Fig 10 show the performance of Channa as an Nanocomposite for varying dosage. About 86.78% of conductivity, 80.00% of TDS, 66.76% of hardness, 92.07% of turbidity was removed with dosage of 0.3g of Channa nanocomposite, initial

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pH was 8.4 and it will be reduced upto 7.26 with the dosage of 0.3g.

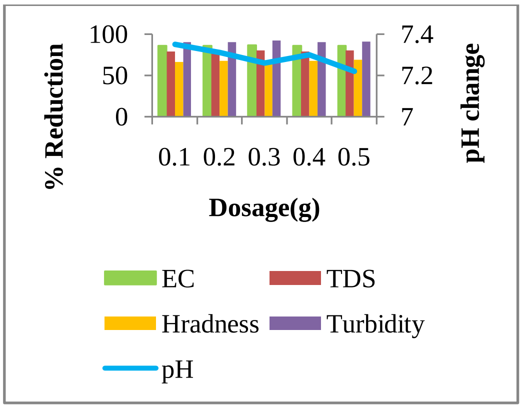

Fig 10: Performance of Channa Nanocomposite as an Adsorbent for Optimum Dosage

Performance of Orange peel as an Nanocomposites for Change in pH

Fig 11 shows the performance of Orange peel as an adsorbent for varaying pHAbout 77.85% of conductivity, 68.91% of TDS, 59.33% of hardness, 77.42% of turbidity was removed with pH 8 of Orange peel.

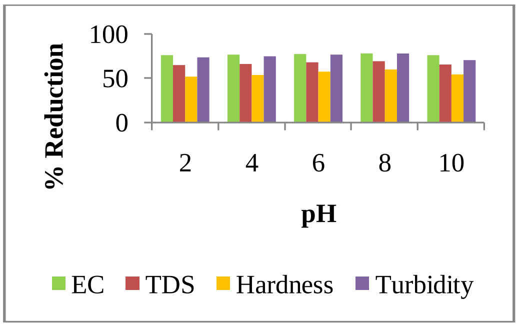

Fig 11: Performance of Orange peel as an Adsorbent for Optimum pH

Performance of Channa as an Adsorbent for Change in pH

Fig 12 shows the performance of Channa as an adsorbent for varayingpH. About 79.64% of conductivity,73.91% of TDS, 66.00% of hradness,85.52 % of turbidity was removed with pH 8 of Channa.

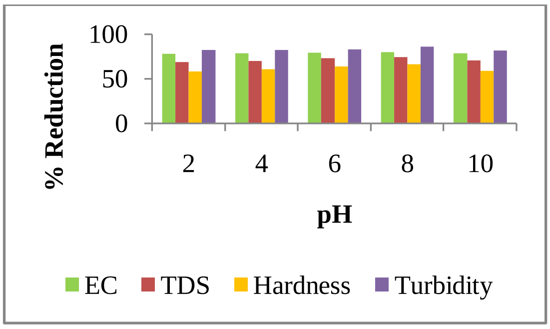

Fig 12: Performance of Channa as an Adsorbent for Optimum pH

Performance of Orange peel as an Nanocomposite for Change in pH

Fig 13 shows the performance of Orange peel as annanoomposite for varying pH. About 83.85% of conductivity,76.89% of TDS, 67.00% of hardness,81.91% of turbidity was removed with pH 8 of Orange peel nanocomposite.

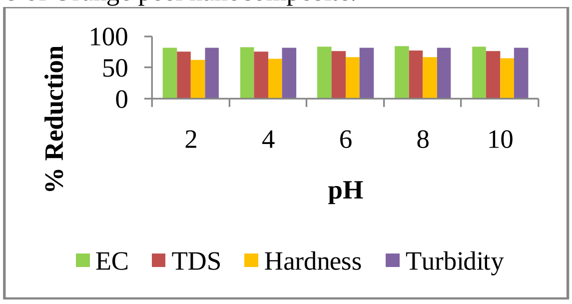

Fig 13: Performance of Orange peel as an Nanocomposite for Optimum pH

Performance of Channa as Nanocomposite for Change in pH

Fig 14 shows the performance of Channa as an nanocomposite for varying pH. About 87.14% of conductivity,83.78% of TDS, 69.33% of hardness,92.17% of turbidity was removed with pH 8 of Channa nanocomposite.

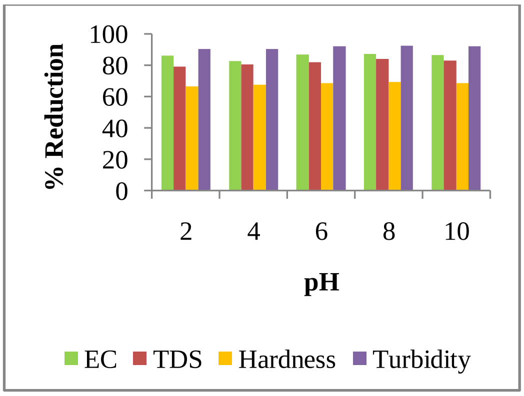

Fig 14: Performance of Channa as an Nanocomposite for Optimum pH

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Performance of Orange peel as an Adsorbent for Change in Contact time

Fig 15 shows the performance of Orange peel as an adsorbent for varying Contact time About 77.85% of conductivity63.71% of TDS, 56.66% of hardness,75.71 % of turbidity was removed with Contact time of 30min of orange peel. Initial pH was 8.4 and it will be reduced upto 7.84 with the contact time of 30 mins

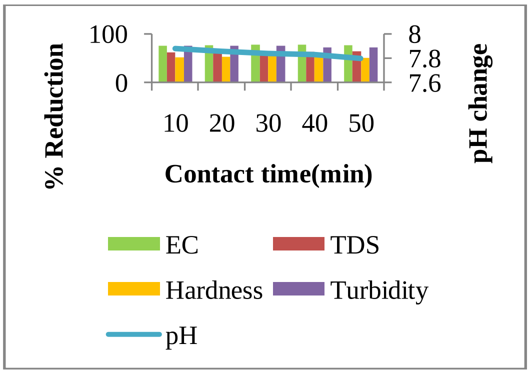

Fig 15: Performance of Orange peel as an Adsorbent forOptimum Contact time

Performance of Channa as an Adsorbent for Change in Contact time

Fig 16 shows the performance of Channa as an adsorbent for varying Contact time. About 80.42% of conductivity 69.32% of TDS, 65.50% of hardness,82.00 % of turbidity was removed with contact time of 30min of Channa. Initial pH was 8.4 and it will be reduced upto 7.75 with the contact time of 30 min**.**

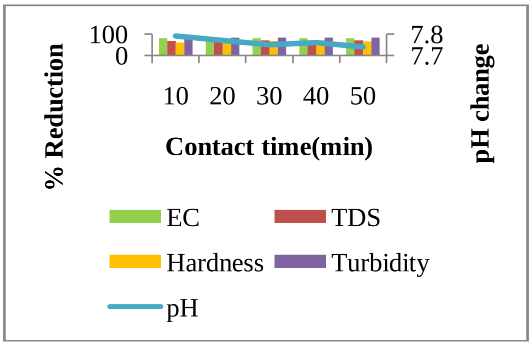

Fig 16: Performance of Channa as an Adsorbent for OptimumContact time

Performance of Orange peel as an Nanocomposite for Change in Contact time

Fig 17 shows the performance of Orange peel as an Nanocomposite for varying Contact time. About 83.00% of conductivity 79.32% of TDS, 66.00% of hardness, 85.52 % of turbidity was removed with Contact time of 30min of orange peel Nanocomposite. Initial pH was 8.4 and it will be reduced upto 7.31 with the contact time of 30 min.

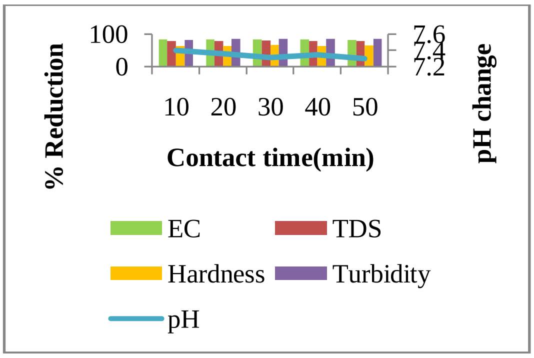

Fig 17: Performance of Orange peel as an Nanocomposite for Optimum Contact time

Performance of Channa as an Nanocomposite for Change in Contact time

Fig 18 shows the performance of Orange peel as an Nanocomposite for varying Contact time. About 83.00% of conductivity 79.32% of TDS, 66.00% of Hradness, 85.52 % of Turbidity was removed with Contact time of 30min of orange peel Nanocomposite. Initial pH was 8.4 and it will be reduced upto 7.31 with the contact time of 30 min.

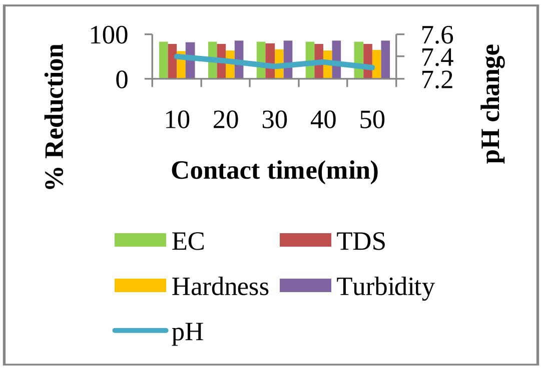

Fig 18: Performance of Channa as an Nanocomposite for Optimum Contact time

IV. CONCLUSION

Turbidity will usually increase during the rainy season due to soil erosion and water flow. If so, at higher levels of complexity the use of a natural adsorbent to remove traces in the water purification process.

Natural products are always better than any other chemical, because they have no harmful effects on human health. In the case of water treatment, chemical coagulants such as alum will work in a person's health and cause many diseases such as Alzheimer's disease. So by avoiding all such kind of problems, natural coagulants are shown to be effective.

When it comes to the good part of these natural coagulants, they are very effective, cost-effective and friendly, reduce the production of large volumes of mud, Sludge produced will be more likely to decompose and reduce ground and groundwater pollution, but mud formed due to natural coagulant can be used as fertilizer, it is very effective , economical and eco-friendly.

The orange peel has the ability to remove turbidity levels up to 76% and Channa has the ability to remove turbidity levels up to 82%. Orange peel Nanocomposite has a turbidity content of up to 83% and Channa Nanocomposite has the ability to remove turbidity levels up to 92%.These results conclude that Nanocomposite was more effective compared to natural adsorbents.

Increase in dosage of Adsorbent and Nanocomposite (Orange peel, Channa) causes significant decrease in TDS, Turbidity, Total hardness, Conductivity till it reaches optimum dosage after that parameters start increasing due to floc destabilization.

Among the two Adsorbents and Nanocomposites used in the study, maximum Turbidity, Conductivity, TDS reduction is found in Channa.

REFERENCES

[1]. Duithy George., and AryaChandrn J.,(2018), “Coagulation Performance Evaluation of Papaya Seed for Purification of River Water”.International Journal of Latest Technology in Engineering Management & Applied Science (IJLTEMAS), Vol. VII, Issue I, 50-66.

[2]. Reena Abraham., Harsha P.,(2019), “ Efficiency of Tamarind and Papaya seed Powder as Natural Coagulant”,International Research Journal of Engineering and Technology (IRJET),Volume: 06 Issue: 04.

[3]. Pifhy Peter M., Habeeba.,(2018), “Turbidity REmoval from Surface Water Using TamarindusIndica as Natural Coagulant”,International Journal of Recent Engineering Research and Development (IJRERD),ISSN: 2455-8761,Volume 03 – Issue 04.

[4]. Lakshmi V., Janani R.V., Anju G.S., Roopa V.,(2007), “ Comparative Study of Natural Coagulants in Removing Turbidity from Industrial Waste Water”, International Journal of Innovative Research in Science, Engineering and Technology ,Vol. 6, Issue 6.

[5]. Lavoine N., Desloges.,Dufresne.,Bras J., (2012), “Microfibrillated Cellulose—Its Barrier Properties and Applications in Cellulosic Materials”,A review. Carbohydr. Polym,90:735–764.

[6]. Amini E.,TajvidiM,,Gardner D.J.,Bousfield D.W.,(2017),“Utilization of Cellulose Nanofibrils as a Binder for Particle Board Manufacture”. Bio Resources;12:4093–4110.

[7]. TajvidiM.,Gardner D.J., Bousfield D.W.,(2016),“Cellulose Nanomaterials as Binders: Laminate and Particulate Systems”,Renew. Mater: 4:365–376.

[8]. Halib N.,Perrone F., Cemazar M., Dapas B.,Farra R.,Abrami M.,Chiarappa., Forte.,Zanconati F.,Pozzato.,(2017), “ Potential Applications of NanocelluloseContaining Materials in the Biomedical Field”,Materials;10:977.

[9]. Rekha Rani., Ajay Singh., Waseem Ahmad.,(2019),“Synthesis of Agro waste Nano Composites Using coconut and rice husk for adsorption of chromium ions”, International Journal of Health and Clinical Research, 2(11):1-4 e-ISSN: 2590-3241, p-ISSN: 2590325X

[10]. NaziaFathima.,UzmaBaig.,Dr.SmitaAsthana. , Dr.D. Sirisha.,(2007), “Removal of Turbidity of Waste Water by Adsorption Technology”, International Journal of Innovative Research in Science, Engineering and Technology, Vol. 5, Issue 11.

[11]. WillougAve.,Suite.,Juneau.,AlaskaDepartment of EnvironmentalConservation, www.dec.alaska.gov(907),465-5185.

[12]. ChandrakalaB.J.,Vasudha.,DR,Mohammed., Yaseen.,Aravinda H.B.,(2017), “Purification of Water Using Low Cost Adsorbents-Fly Ash and Activated Carbon”, IJSART - Volume3,Issue6-ISSN[ONLINE]:2395-1052.

[13]. Abirami.M., Rohini C.,(2017),“A Comparative Study on the Treatment of Turbid Water Using MoringaOleifera and Alum as Coagulants”, International Conference on Emerging trends in Engineering, Science and Sustainable Technology.

[14]. KavyaGurumath.,Dr.S.Suresh.,(2019), “CicerArietinum Is Used As Natural Coagulant For Water Treatment”,International Research Journal of Engineering and Technology (IRJET),e-ISSN: 2395-0056, Volume: 06 Issue: 07 .

[15]. Priyatharishini N. M., Mokhtar R. A., Kristanti.,(2019), “Study on the Effectiveness of Banana Peel Coagulant in

Turbidity Reduction of Synthetic Wastewater", International Journal Of Engineering Technology And Sciences (IJETS) ISSN: 2289-697X (Print); ISSN: 2462-1269 (Online) Vol.6 (1).

[16]. Manjunatha K R., Vagish M.,(2016), "Study On Adsorption Efficiency Of Neem Leaves Powder In Removal Of Reactive Red Dye Color From Aqueous Solution",International Research Journal of Engineering and Technology (IRJET),Volume: 03 Issue: 07.

[17]. Sukhdeep Singh.,(2017), "Turbidity Removal from Water by Use of Different Additive Materials" , International Journal of Scientific Engineering and Science Volume 1, Issue 10, pp. 55-57.

[18]. Kokila A., Parmar, Sarju P., RinkuP.,andYogesh D.,(2011), "Effective use of Ferrous Sulfate and Alum as a Coagulant in Treatment of Dairy Industry Wastewater", ARPN Journal of Engineering and Applied Sciences 6(9):42-45.

[19]. Asha D. R., Nandini and Jagannath S., (2013), "Coagulation Efficiency of MangiferaIndica Linn.inComparision with Alum and MoringaOleifera Lam", Journal of Bioscience and Informatics 4(3):240-252.

[20]. GrégorioCrini., Eric Lichtfouse., Lee Wilson., Nadia Morin-Crini.,(2019), "Conventional and non-conventional adsorbents for wastewater treatment", Environmental Chemistry Letters, Springer Verlag, pp.195-213.

[21]. Ashutosh Tripathi. ,and ManjuRawatRanjan., "Heavy Metal Removal from Wastewater Using Low Cost Adsorbents", Journal of Bioremediation & Bio degradation, 2015, Vol.6, pp.2155-6199.

[22]. Yasmin M.,Regina S., Saraswathy B., Kamal V., Karthik., K Muthukumaran.,(2015),"Removal Of Nickel Ions From Waste Water Using Low Cost Adsorbents", Journal of Chemical and Pharmaceutical Sciences, 2015, Vol.8.

[23]. https://simple.m.wikipedia.org/wiki/orange-(fruit).

[24]. https://en.m.wikipedia.org/wiki/chickpea.

[25]. Nik-Abdul-Ghani N. R., Jami M. S.,andAlam M. Z.,(2021), "The role of nanoadsorbents and nanocomposite adsorbents in the removal of heavy metals from wastewater",7(1):153-179,Review Paper DOI: 10.22059/poll.2020.307069.859 Print ISSN: 2383-451X.

[26]. Li Y.H., Di Z., Ding J.,Wu D., Luan Z., and ZhuY., (2005), "Adsorption thermodynamic, kinetic and desorption studies of Pb2+ on carbon nanotubes", Water Res., 39(4), 605–609.

[27]. Liu D., Zhu Y., Li Z., Tian D., Chen L., and Chen P., (2013), "Chitin nanofibrils for rapid and efficient removal of metal ions from water system. Carbohydr.Polym., 98(1), 483–489. 153 .

[28]. Nik-Abdul-Ghani N. R., Jami M. S., and Alam M. Z ., "The role of nanoadsorbents and nanocomposite adsorbents in the removal of heavy metals from wastewater", A review and prospect.

[29]. Hua M., Zhang S., Pan B., Zhang W., LvL,and Zhang Q,. (2012), " Heavy metal removal from water/wastewater by nanosized metal oxides", A review. J. Hazard. Mater., 211–212, 317–331.

[30]. Burakov A. E., Galunin E. V., Burakova I. V., Kucherova A. E., Agarwal S., Tkachev A. G., and Gupta V. K., (2018). "Adsorption of heavy metals on conventional and nanostructured materials for wastewater treatment purposes", A review. Ecotoxicol. Environ. Saf., 148, 702–712.

[31]. Lofrano G., Carotenuto M., Libralato G., Domingos R. F., Markus A., Dini L., Gautam R. K., Baldantoni D., Rossi M., Sharma S. K., Chattopadhyaya M. C., Giugni M. and Meric S., (2016). " Polymer functionalized nanocomposites for metals removal from water and wastewater: An overview",Water Res., 92, 22–37.

[32]. https://en.m.wikipedia.org/wiki/Nanocomposite.

[33]. Amini E.,TajvidiM.,Gardner D.J., Bousfield D.W.,(2017), "Utilization of cellulose nanofibrils as a binder for particleboard manufacture"Bio Resources 2017;12:4093.

[34]. Halib N., Perrone F.,Cemazar M., Dapas B.,Farra R.,Abrami M.,ChiarappaG.,Forte G.,Zanconati F.,Pozzato G.,(2017), " Potential applications of nanocellulose-containing materials in the biomedical field".

[35]. Tajvidi M., Gardner D.J.,Bousfield D.W.,(2016), "Cellulose nanomaterials as binders Laminate and particulate systems",J. Renew Mater,4:365–376.

[36]. Jeong B.H., (2007), "Interfacial polymerization of thin film nanocomposites: a new concept for reverse osmosis membranes". J MembrSci 294(1–2):1–7.

[37]. Nirmale, T. Kale., Varma, A.,(2017), "A review on cellulose and lignin based binders and electrodes: Small steps towards a

sustainable lithium ion battery",Int. J. Biol. Macromol, 103: 1032–1043.

[38]. Zhang Y., Nypelö T., Salas C., Arboleda J., Hoeger I.C., Rojas O.J.,(2013), "Cellulose nanofibrils: From strong materials to bioactive surfaces", J. Renew. Mater1,195–211.

[39]. Gehrke I., Geiser A., Somborn-Schulz A.,(2015), " Innovations in nanotechnology for water treatment". NanotechnolSciAppl 8:1–17.

[40]. Jeong BH., (2007), "Interfacial polymerization of thin film nanocomposites: a new concept for reverse osmosis membranes", J MembrSci 294(1–2):1–7.

[41]. Lee A, Elam JW, Darling SB., (2016), "Membrane materials for water purification: design, development, and application",EnvironSci Water Res Technol 2(1):17–42.