ADSORPTION OF PHOSPHATE FROM AGRICULTURAL RUNOFF BY ACTIVATED CARBON PREPARED FROM MANILKARA ZAPOTA

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Abstract Adsorption technology is one of the most popular methods for treating wastewater and water. Agricultural runoff consists of phosphate. Utilizing activated carbon prepared from Manilkara Zapota seed, an attempt is made to find a naturally occurring, inexpensive, and effective adsorbent. Investigating the physio-chemical properties of activated carbon made from Manilkara Zapota is one of the objectives of this study. Analysis of the relationship between contact time, adsorbent dosage, and pH and the amount of phosphate extracted by the adsorbent.The study revealed that 35 min with a removal efficiency of 86.95% is the ideal contact period for physically activated carbon to remove phosphate. And chemically activated carbon using different IR ratios of 0.25, 0.50, and 0.75 revealed a value of 35min, 25min & 20min with removing efficiency of 88.69%, 94.95% & 95.65%. The best Optimum dosage for physically activated carbon to remove phosphate is 1500 mg/L, with a removal efficiency of 82.08%. And chemically activated carbon using different IR ratios of 0.25, 0.50, and 0.75 revealed a value of 1500 mg/L,1000 mg/L &1000 mg/L with percentage removal efficiency of 95.65%, 96.0% & 97.7%. The best pH for physically activating carbon to remove phosphate is 4.5, and removal effectiveness is 98.78 percent. And chemically activated carbon using IR ratios of 0.25, 0.50, and 0.75 revealed a value optimum pH of corresponding removal efficiency of 99.13%, 99.40% & 99.80%.

***Index Terms* – Phosphate, Adsorption, activated carbon, contact time, Dosage, pH.**

I. INTRODUCTION

Water is a crucial component of our planet Water is a necessity for all living things to survive. Non-living beings will survive without water. In comparison to the total amount of water on the planet, humans only have access to 2.5% of freshwater. Glaciers and ice caps account for 68.7 percent of this, leaving us with just 30.1 percent of groundwater and 1.2 percent of surface water. All around the world, there is a considerable increase in the need for freshwater for numerous purposes, including residential, irrigation, industry, and others. So, the treatment of wastewater is a must need in present days [1].

A surplus of phosphorus in wastewater sources. encourages the development of dangerous cyanobacteria and photosynthetic algae. Diverse methods have been used to remove phosphate from wastewater, but the most popular ones are adsorption, biological processes, biological treatments, chemical precipitation using calcium, iron, or aluminum salts, ion exchange, coagulation-flocculation, adsorption onto clay, and activated carbon [2]

Therefore, removing phosphate ions from wastewater is essential for preventing eutrophication and other health problems associated with this sorbate. The biological treatment and chemical precipitation are less successful when there is a low concentration of phosphate ions, such as in stormwater runoff.

II. OBJECTIVE OF THE STUDY

1) Preparing activated carbon using physical and chemical means.
2) Analyzing of Physico-chemical properties of the carbon derived from Manilkara zapota seed.
3) Analyzing the effects of contact time, adsorbent dosage, and pH on the removal of phosphate.

III. LITERATURE REVIEW

SIVA PRASAD SHYAM, JAYASEELAN ARUN, KANNAPPAN PANCHAMOORTHY GOPINATH, GAUTAM RIBHU D, MANANDHAR ASHISH, SHAH AJAY (JANUARY 2022)

Have been studied on the removal of phosphorous using hydrochar & biochar as an adsorbent which is mainly present in water bodies [1].

ISMAIL W. ALMANASSRA, VIKTOR KOCHKODAN, GORDON MCKAY, MUATAZ ALI ATIEH, TAREQ AL-ANSARI (FEBRUARY 2021)

The literature on the adsorptive removal of phosphate using several carbon-based adsorbents, such as activated carbon, charcoal, graphene, graphene oxide, graphite, and carbon nanotubes, is reviewed in this paper. The effects of coexisting ions, thermodynamics, insights into the adsorption behaviour, experimental parameters, mechanisms, and potential desorption processes of phosphate onto modified and unmodified carbonaceous adsorbents are also taken into account. In conclusion, research issues and gaps have been identified.[3].

IV. MATERIAL AND METHODOLOGY

The naturally available Manilkara Zapota seed is taken as study material (adsorbent) for the removal of Phosphate from its Agricultural runoff.

Manilkara zapota, also known as sapodilla, sapota, chikoo, chico, naseberry, or nispero, is a long-lived evergreen tree that is indigenous to southern Mexico, Central America, and the Caribbean (the seed is depicted in Figure 2). Additionally, it is a subdominant plant species in the Petunes mangroves ecoregion along the coast of Yucatán. It arrived in the Philippines as a result of Spanish colonisation. It is extensively grown in Thailand, Malaysia, Cambodia, Indonesia, Vietnam, Bangladesh, Pakistan, Thailand, and Mexico.

Figure 1 :Manilkara Zapota Tree

Figure 2: Manilkara Zapota Seed

Utilizing activated carbon made from Manilkara Zapota seed as an adsorbent to remove phosphate from agricultural runoff. The two ways to make activated carbon are as follows:

1. Physical activation.
2. Use of $CaCl_2$ in chemical activation with various impregnation ratios (I.R) of 0.25, 0.5, and 0.75, respectively.

Physical activation: The Manilkara Zapota seed is cleaned, ground to the appropriate sizes, and then washed three to four times in distilled water. After that, the powder is dried in an oven at 100±5°C for 24 hours. The oven-dried powder is packed into a small container in three layers, with no air spaces between them to prevent the powder from losing weight. If this were to happen, the material would burn up completely, leaving only ash behind. The little container is then placed within a larger container, which is encircled by sand and has a tightly fitting lid. The container lids have been punctured with pinholes to allow organic vapors to escape.

The setup is then placed in a muffle furnace and heated to an internal temperature of 800°C gradually. The furnace was allowed to cool for roughly 10 hours before the container was removed. The resulting activated carbon is sieved to a 300µ passing 150µ retained before being placed in polyethylene bags and kept in a desiccator.

Chemical Activation: Activating agent ($CaCl_2$) is combined with known quantities of washed and dried Manilkara Zapota seed powder of size 150µ depending on the impregnation ratio (I.R). The necessary amount of distilled water was added to that combination and cooked on a hot plate until the majority of the water evaporated and the mixture remained slurry-like. The remaining moisture in the mixture was subsequently removed by drying it for 24 hours at 100°C in the oven. The method indicated above involved pouring a preheated carbonising substance into a tiny container to carbonise.

The method described for physical activation is used. The resulting activated carbon was then rinsed six to eight times in hot distilled water to eliminate any traces of HCl and 0.1N HCl to remove the activating agent. The activated carbon was dried at 100°C for 5 minutes before being placed in polythene bags and kept in a desiccator. The physicochemical characteristics of generated carbons are shown in Table 1.

Table -1: Physico-chemical properties of prepared carbons

Types of carbon	**Physically Activated**	**Chemically Activated $CaCl_2$**		
I.R	-	0.25	0.5	0.75
% Moisture content	8	13	15	19
% Ash content	14	20.69	22.32	26.51
pH	9.10	7.1	6.76	6.50
Surface area (m^2/gm)	531.15	594.39	872.59	962.68
Specific gravity	1.15	1.00	1.04	1.14
Bulk Density (g/cm^3)	0.331	0.432	0.424	0.411

V. RESULTS AND DISCUSSIONS

The efficiency of naturally available adsorbents in removing Phosphate as a function of:

1. Contact time
2. Dosage
3. pH were studied.

1. **Effect of Contact Time**: The effect of contact time on the removal of Phosphate from their agricultural runoff sample on physically and chemically activated ($CaCl_2$) carbons prepared from Manilkara Zapota seed are analyzed. For physically and chemically activated carbon with particle sizes 150µ and I.R. 0.25, 0.50, and 0.75 are used. It is observed that contact time differs for different carbons i.e. for physically and chemically activated carbons. From the Fig:3 and Fig:4, it is evident that the extent of Phosphate adsorption increases with an increase in time. The adsorption curves are characterized by a sharp rise in the initial stage and decreases near equilibrium. This is mainly due to the large available surface area and the adsorption sites on the surface area that are open and active in the initial stage and later the adsorbent gets saturated and the removal efficiency decreases near equilibrium. After equilibrium further increases in time, adsorption is not changing. Hence, the removal efficiency of Phosphate by using physically activated carbon is found to be 86.95 % with an optimum contact time of 35min, and the removal efficiency of Phosphate by using chemically activated carbon ($CaCl_2$) with different I.R 0.25, 0.5, and 0.75 are found to be 88.69%, 94.95%, 95.65% with an optimum contact time of 35min, 25min and 20 min respectively.
   Compared to chemically activated carbon, physically activated carbon is less efficient. When compared to I.R 0.5 and 0.25, the chemically activated carbon with I.R 0.75 had a higher removal efficiency for phosphate. this results from the surface area of carbon increasing as I.R increases, which causes the carbon to adsorb more phosphate..

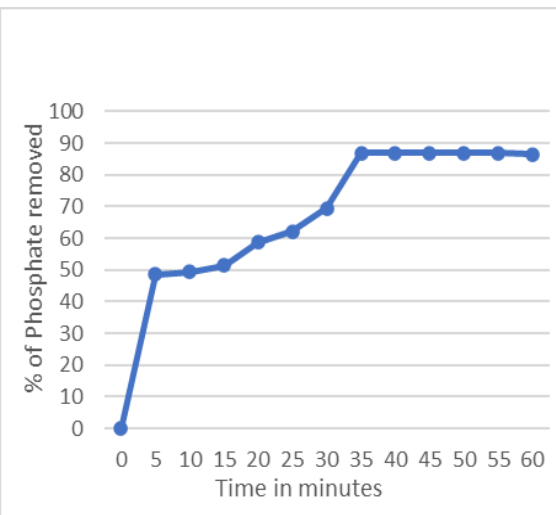


Fig:3 effect of contact time on physically activated carbon

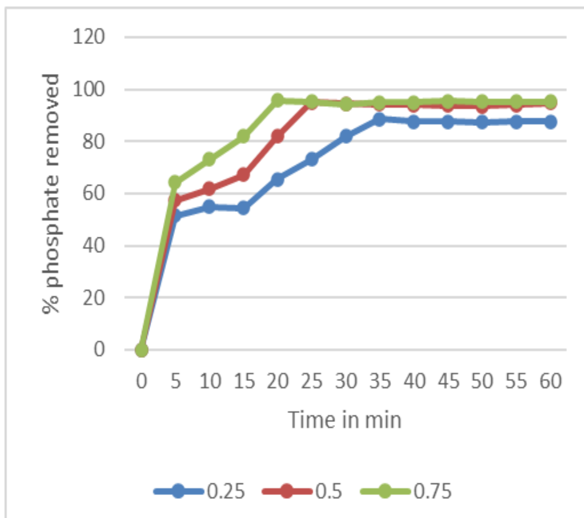
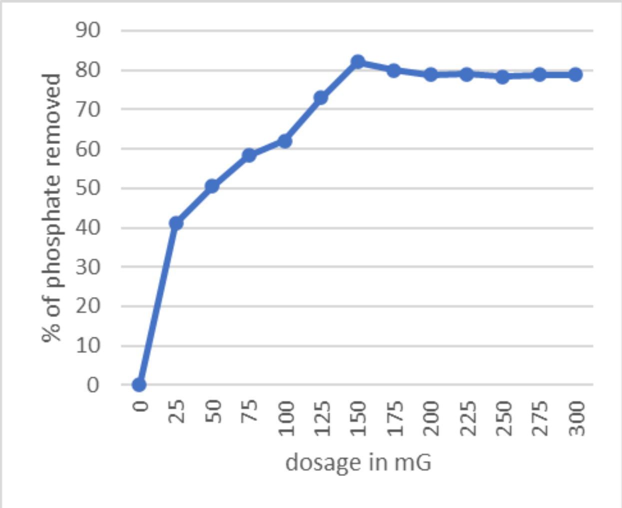


Fig:4 effect of contact time on chemically activated carbon $CaCl_2$

Effect of Adsorbent Dosage: A solute is continuously transferred from a solution to an adsorbent during the adsorption process, which lasts until the residual concentration of the solution maintains equilibrium with the solute being adsorbed by the surface of the adsorbent at a constant contact time. As a result, the removal efficiency of phosphate using physically activated carbon was found to be 82.08 percent with an optimal dosage of 6000 mg/L, and the removal efficiency of phosphate using chemically activated carbon (CaCl2) with different I.R 0.25, 0.5, and 0.75 was found to be 95.65 percent, 96 percent, and 72.97 percent with optimal dosages of 150 mg, 1000 mg, and 1000 mg/L, respectively. Figures 5 and 6 illustrate the effect of the investigated adsorbent dosages as well as the percentage of phosphate removal versus dosage.

According to Figs. 5 and 6, the amount of phosphate in the samples reduces significantly at first and then reaches equilibrium as the dosage of adsorbents rises. The locations that are open for adsorption are primarily to blame for this. Later, the adsorbents become saturated, and their ability to remove substances declines. After then, despite increasing the adsorbent dosage, not many changes are seen.



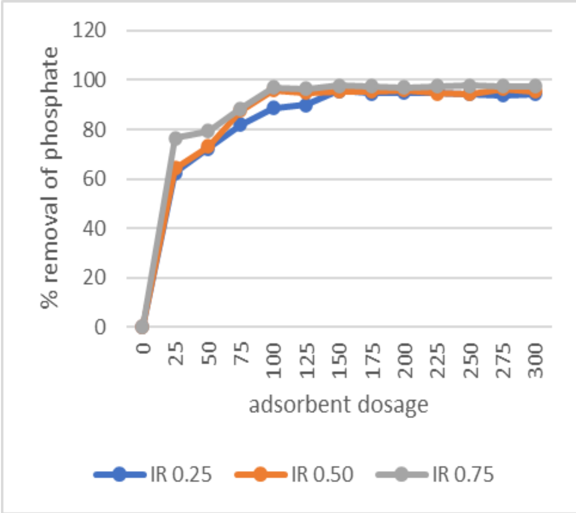
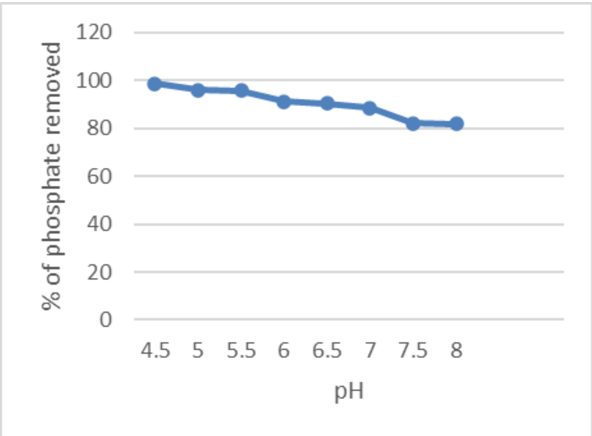


Fig:5 effect of optimum dosage on physically activated carbon

Fig:6 effect of optimum dosage on chemically activated carbon $CaCl_2$

Effect of pH: The extent of the removal of phosphate by naturally occurring adsorbents at various pH levels is affected by the pH of the solution. The corresponding figures in Figures 7 and 8 illustrate how pH affects phosphate removal in addition to surface area, optimal time, and dosage. Phosphate is found to be eliminated more efficiently in the acidic range. CaCl2 activated carbon at varied I.R. 0.25, 0.50, and 0.75 is shown to have a 99.13 percent, 99.40 percent, and 99.80 percent removal efficiency of phosphate when physically activated, respectively.From the below figures, it is observed that Phosphate is removed more effectively in the acidic range for physically and chemically activated carbon.



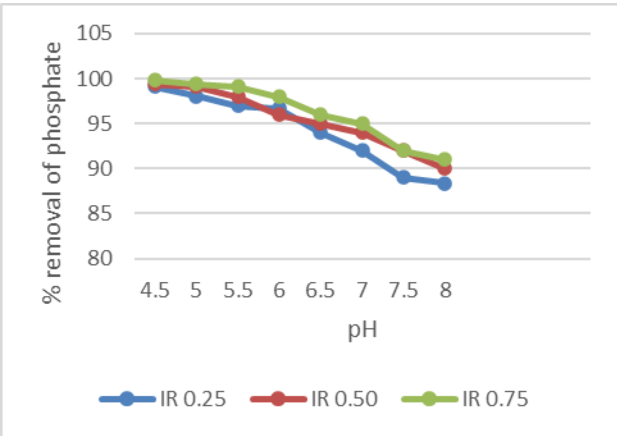


Fig:7 effect oh pH on physically activated caron

Fig:8 effect oh pH on chemically activated carbon $CaCl_2$

VI. CONCLUSIONS:

Based on the results following conclusions are drawn

The Physico-chemical properties prepared from Manilkara Zapota seed for physically and chemically ($CaCl_2$) activated carbon of $CaCl_2$ (IR 0.25,0.50,0.75) are:

1. The moisture content for physically activated carbon is 8% and for chemically activated carbon of different IRs is 13%, 15%, and 19%.
2. The ash content for physically activated carbon is 14% and for chemically activated carbon of different IRs is 20.69%, 22.32%, and 26.51%.
3. The pH for physically activated carbon is 9.10 and for chemically activated carbon of different IRs is 7.1, and 6.76, 6.50.
4. The Surface area for physically activated carbon is 531.15 m^2/gm and for chemically activated carbon of different IRs 594.39 m^2/gm, 872.59 m^2/gm, and 962.68 m^2/gm.
5. The Specific gravity for physically activated carbon is 1.15 and for chemically activated carbon of different IRs is 1.00, and 1.04, 1.14.
6. The Bulk density for physically activated carbon is 0.331 g/cm^3 and for chemically activated carbon of different IRs is 0.432 g/cm^3, 0.424 g/$cm^{3,}$ and, 0.411 g/cm^3.

7. The experiment's findings showed that phosphate removal rises with longer contact times and reaches equilibrium at a certain point. The removal efficiency of phosphate utilising chemically activated carbon (CaCl2) with varied I.R 0.25, 0.5, and 0.75 is determined to be 88.69 percent, 94.95 percent, and 95.65 percent with an optimal contact duration of 35 min, 25 min, and 20 min correspondingly.

8. The result of an experiment on the optimum dosage of adsorbent reveals that an increase in the amount of dosage added increases the removal of phosphate from the solutions. Hence the removal efficiency of phosphate by using physically activated carbon was found to be 82.08% with an optimum dosage of 1500mg/L, and the removal efficiency of phosphate by using chemically activated carbon ($CaCl_2$) with different I.R 0.25,0.5,0.75 was found to be 95.65%, 96.00%, 97.7% with an optimum dosage of 1500mg/L, 1000mg/L, 1000mg/L respectively.

9. Phosphate adsorption is primarily pH-dependent. With a drop in pH, the adsorbent's removal effectiveness rises. Maximum adsorption has been shown to occur in acidic media at pH 4 and 5, respectively. Physically activated carbon was shown to have a 98.78 percent removal efficiency for phosphate, and CaCl2 activated carbon at different I.R.s of 0.25, 0.50, and 0.75 was found to have a 99.13 percent, 99.40 percent, and 99.80 percent removal efficiency, respectively.

10. The adsorption capacity of physically activated carbon is 2.74mg/gm and for chemically activated carbon of different IRs is 2.74mg/gm, 2.32mg/gm, and 2.32mg/gm.

VII. ACKNOWLEDGEMENT

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VIII. REFERENCES:

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