

Preparation of Sustainable Adsorbent to Treat Organic Pollution in Water

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Abstract: Are your thoughts knocking on your mind that Earth is standing on the corner of destruction and soon it will fall down? That's mean your thoughts are challenging human ingenuity. No doubt world is facing various significant concerns associated with Environment. However, water is revealed as a major concern of this contemporary epoch. All concerns need equal attention, but water is a primary need as life is not possible without water. Enormous techniques have brought in front to bring water pollution at acceptable levels but some of them show cons in terms of unsustainability while others in terms of high cost and there are very few available techniques to overcome organic pollution. Keeping all these circumstances into consideration; this paper presents sustainable and cost-effective adsorbent; will be known by world as SUNSPACE to reduce organic pollution in water. With the help of UV spectrophotometer; efficiency of SUNSPACE is observed by comparing before and after water samples using SUNSPACE. This adsorbent is associated with remarkable environmental and economic advantages; these advantages will make the adsorbent a very noticeable technique in the time to come.

Keywords: Adsorbent, Algae, Organic Pollution, Sustainability.

I. INTRODUCTION

The 18th century, the century of industrial revolution, the century of modern technologies and the century in which hand work was started to be converted into the machine work. Concept of development was commenced in 18th century or one should say together with development, the destruction of Environment was commenced. All countries are in the race of being most powerful country of the world; country with advance technologies and powerful weapons are considered as the superior of the world. Various advance technologies degrade Environment from their cradle to grave period. Environmental degradation can be explained in terms of Water pollution, Air pollution, soil pollution and so forth, development is degrading these precious resources of universe. Among all these, water pollution is concluded as a major disaster of this era. The wastewater from industries, textile sectors, agricultural sectors, houses, power plants and other from sources is discharged directly into the river, lake, canal, without any treatment that cause various serious health issues and deteriorates quality of water. The major role in deterioration of water quality is played by organic matter, as organic matter is present in dissolved form thus it is difficult to remove organic matter from water.

If it is said that Earth will destroy soon then that's mean human intelligence is being target of doubts. If humans are the polluters of Environment, then humans are also the healers of Environment. Different Researchers have brought forward various water pollution dealing techniques, but their high cost and associated drawbacks heal one part of Environment and degrade the other part of Environment (Salvatore Di Falco, 2012). Among all existing techniques for the treatment of water, adsorption is considered as most feasible for practical use. Activated carbon is one of best adsorbent available today to treat water, however it is not suitable for practical use because manufacturing process of activated carbon releases tonnes of greenhouse gases (Hjaila et, 2013). Activated carbon treats one resource of Environment i.e. water and pollutes other resource of Environment i.e. air.

Keeping high cost and unsustainability of available techniques, this paper brings forward an adsorbent that has property of adsorbing organic matter from water, composed of cheap materials and its remarkable property make it sustainable material. The adsorbent has been named as SUSPACE (sustainable material synthesized from by-products and Alginates for Clean air and better Environment) by their developers. (Zanoletti et al, 2018) prepared SUNSPACE by using Sodium Alginate, Calcium Chloride, De-ionized water, Silica Fume and Sodium Bi-carbonate. In this work, SUNSPACE is composed of Sodium Alginate, Calcium Chloride, De-ionized water, Cement (due to unavailability of Silica Fume), Sodium Bi-carbonate and Algae. Algae is added in the composition of adsorbent to analyse the effects of Algae on adsorbent's efficiency as algae is best adsorbent among existing ones used to treat of water. Two algal species i.e. Oedogonium and Spirogyra are added in the composition of adsorbent. In order to complete this research work, three objectives were set.

1. To synthesize the Sustainable Adsorbent (SUNSPACE).
2. To determine the efficiency of Adsorbent for the removal of Organic Matter.
3. To compare adsorbent with and without Algae.

This adsorbent has not made available in market yet, researchers have just tested adsorbent on model solution thereby this adsorbent is still under research. This paper aims to make adsorbent more efficient by including algae in the composition of SUNSPACE and recommends the experts of Pakistan to give their focus on this adsorbent because this adsorbent can become a leading technique of future to treat water and air pollution as well. This papers solely focus on the removal of organic matter, but developers of adsorbent have concluded that SUNSPACE has potential to adsorb organic matter and heavy matter from water and particulate matter from air.

II. LITERATURE REVIEW

(Zanoletti et al, 2019) summarized that adsorbent (SUNSPACE) has property to capture particulate matters from air. Urban air pollution can be reduced by coating SUNSPACE on roofs and walls.

(Roonak Amiri et al, 2019) investigated that Spirogyra algae is the best wastewater treatment biosorbent; that captures impurities from wastewater and accumulates impurities in its pores structure and purifies the water.

(Zanoletti et al, 2018) prepared eco-friendly mesoporous hybrid material SUNSPACE (sustainable material synthesized from by-products and Alginates for Clean air and better Environment); composed of natural abundant and raw-materials from industries. The material has dual property to purify water as well as air. Adsorbent is tested on Methylene blue solution to compare efficiency of SUNSPACE with Activated carbon. SUNSPACE showed 94% efficiency. It was concluded that SUNSPACE is more efficient than Activated Carbon.

(Dorota et al, 2018) concluded that Organic matter has complex nature; UV Spectrophotometer is observed as the best technique among all to determine the concentration of organic matter at 204 nm, 254 nm, 365nm and 436 nm.

(Hasti Hosseinizand et al, 2017) suggested that algae may change its structure and composition by the increase of temperature thereby suitable temperature to obtain dry algal mass is 60-80 °C.

(Singh et al, 2016) deduced that Silica Fume and Cement possess same physical properties; these both are used to increase the mechanical strength of material. Cement is being replaced with Silica Fume in construction work as Silica Fume provides higher strength than Cement. However, these both can be used in place of each other.

(Arya Krishnan et al, 2013) used Oedogonium algae on synthetic water in order to analyse the efficiency of algae in removing organic and inorganic matter from synthetic water. It is observed that 54.12 %, 93.07 %, 78.64 %, 53.97 %, 47.12 % and 77.33

% of TDS, Turbidity, BOD, COD, Ammonia Nitrogen and Phosphorus respectively are removed from synthetic water. (Alkbrektiene et al, 2012) Concluded that UV245 is one of most efficient and time saving method to determine the concentration of organic matter in ground water. Other methods of determining the organic concentration in water i.e. TOC, COD and DOC are not considered suitable as these methods require enough time and require chemicals that possess harmful effects.

(QIN BoQiang et al, 2012) researched that algae disturbs the ecosystem of water bodies. High concentration of Nitrogen and Phosphorus causes eutrophication in water bodies and eutrophication blocks sunlight from entering into water bodies thereby aquatic biodiversity does not get sufficient sunlight and ecosystem of lake becomes unstable.

(Qing LI et al, 2006) analyzed that after specific period of time, organic compounds present in water bodies are transformed into persistent organic pollutants. Persistent organic pollutants are those which show the resistant against process of degradation thus remains in water bodies forever. Presence of non-degradable compounds in water bodies disturbs ecological cycles and possesses various serious threats towards aquatic and human life.

III. MATERIAL AND METHODS

3.1 Materials

Sunspace is composed of following materials:

- 1: Sodium Alginate (bought from DEAJUNG Company).
- 2: Double Deionized Water (Purchased from Globe Scientific Store).
- 3: Calcium Chloride (Purchased from Globe Scientific Store).
- 5: Cement (purchased from Deewan Cement and Construction Works).
- 6: Sodium Carbonate. (Purchased from Globe Scientific Store).
- 7: Algae (Collected from pond near License Office).

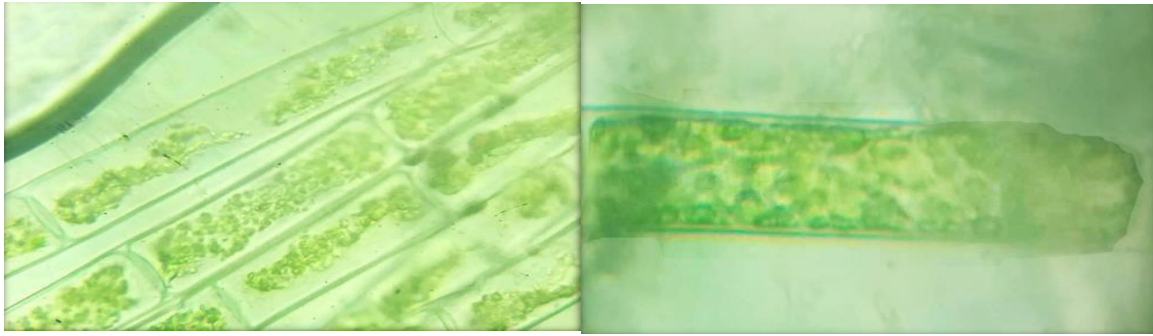


Figure 3.1 Oedogonium Algae

Figure 3.2 Spirogyra Algae

3.2 Synthesis Methods

3.2.1 Algal Dry Mass

- ✓ Algae is collected from pond located near License Office.
- ✓ Algae is properly washed.
- ✓ Washed Algae is filled into beakers.
- ✓ Beakers are kept in oven at 60 °C for 1 day (24 hours).
- ✓ After keeping Algae 24 hours in oven, dry mass of Algae is obtained.
- ✓ To convert Algal dry mass into powder form, dry mass is grinded into grinder.
- ✓ Powdered form of Algae is passed from sieve.

3.2.2 Adsorbent (SUNSPACE)

- ✓ 0.6 gram of Sodium Alginate is added into 25 ml de-ionized water, stirred until transparent solution is obtained.
- ✓ Dry Mass of Algae is added into obtained transparent solution, 0.4 gram of Oedogonium and 0.4 gram of Spirogyra are used to prepare algal based SUNSPACE samples. (Skip this step in non-algal based adsorbent).
- ✓ 1 g of calcium chloride (used as cross linker) is added in water-sodium alginate solution under continual mixing; at these conditions a gel is obtained.
- ✓ Slurry is placed into oven at 70-80 °C for 1 hour. At temperature of the 70-80 °C solubility of $(Ca(IO_4)_2)$ is increased and Ca^{2+} ions are released rapidly this rapid release of calcium ions increases the rate of gelatin process of sodium alginate and hybrid material consolidation. At the same time thermal decomposition of sodium bicarbonate take place, and pores are formed due to consequent release of CO_2 .
- ✓ Adsorbent obtained after placing in oven is filled into desired shape and left for 1 to 2 days (depend on room temperature) at room temperature so that it achieves mechanical strength.
- ✓ Then adsorbent is placed into muffle for 1 minute at 400 °C and after taking out adsorbent from muffle furnace now adsorbent is ready for use (Annealing Step).
- ✓ Obtained SUNSPACE is converted into powdered form using grinder and then sieved.
- ✓ Adsorbent is rinsed into de-ionized water to remove water soluble compounds.
- ✓ Adsorbent is then filtered from double de-ionized water and dried at room temperature.
- ✓ Obtained SUNSPACE is converted into powdered form using grinder and then sieved.



Figure 3.3 Synthesized Adsorbent

3.3 Experimental Section

3.3.1 Sample Synthesizing Measurements

- ❖ 200 ml of wastewater are taken by using graduated cylinder.
- ❖ Four SUNSPACE samples are taken i.e.
 - 1: Pure Adsorbent / Adsorbent without Algae.
 - 2: Oedogonium based adsorbent.
 - 3: Spirogyra based adsorbent.
- ❖ 0.125 gram of each adsorbent are taken (previous study suggests 0.125 gram).

3.3.2 Experiment

- ❖ Ground water is taken as sample water and filtered to make water free from undissolved particles.
- ❖ In 50 ml of filtered water, 0.125 gram of sunspace are mixed. In this way, three sample are prepared, one non-algal based and two algal based adsorbents.
- ❖ Three prepared samples are placed at shaker for specific time period at 80 rpm.
- ❖ After specific period of time, all samples are filtered to separate SUNSPACE from ground water (After SUNSPACE sample)
- ❖ Extra 50 ml of filtered ground water are filtered again to use as before SUNSPACE sample.

3.3.3 Testing

- ❖ By using UV spectrophotometer, concentration of organic matter in before and after samples at 254 nm and 365 nm is analyzed and with the help of following formula, removal efficiency of SUNSPACE is calculated.

$$\eta = \frac{C_i - C_f}{C_i} \times 100$$

Here

C_i = Concentration of organic matter present in before using SUNSPACE wastewater sample.

C_f = Concentration of organic matter remained in After SUNSPACE wastewater sample.

IV. RESULTS AND DISCUSSION

4.1 Material Characterization

with the help of FTIR technique, adsorbent is characterized before and after contacting with wastewater in order to know about the chemistry exist behind the adsorbent and to observe interaction between groups of organic pollutants and adsorbent.

4.1.1 Characterization of Pure Adsorbent

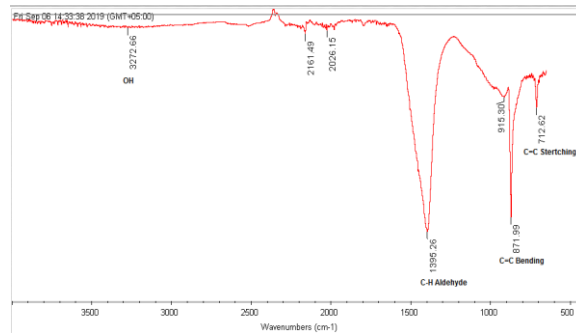


Fig 4.1 Characterization of Pure adsorbent before contacting with wastewater

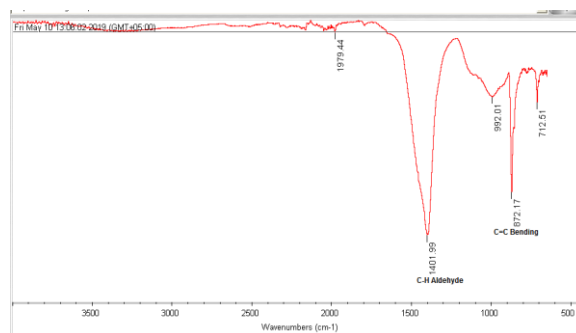


Fig 4.2 Characterization of Pure adsorbent after contacting with wastewater

If Fig 4.1 and 4.2 are compared, then it is obvious that in Fig 4.1 hydroxyl group is present while it is absent in Fig 4.2 and there are variations in wavenumbers of Carbon-Aldehyde Group and Carbon-Carbon Group in before and after graphs which show the interaction of adsorbent with pollutants.

4.1.2 Characterization of Oedogonium Algal based adsorbent

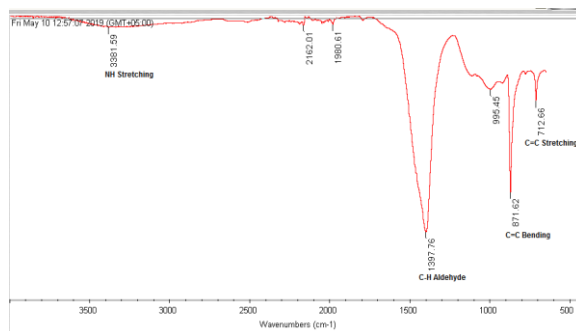


Fig 4.3 Characterization of Oedogonium based adsorbent before contacting with wastewater

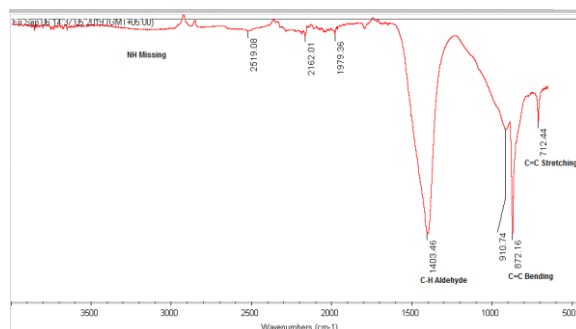


Fig 4.4 Characterization of Oedogonium based adsorbent after contacting with wastewater

From comparison Fig 4.3 and Fig 4.4, it is observed that amine group was present in composition of adsorbent and then as adsorbent is contacted with wastewater, amine is diminished and variations in wavenumbers of present groups shows the interaction of adsorbent with pollutants. Here, interaction of adsorbent is noticed with amine group which is inorganic group thereby presence of algae makes the adsorbent also suitable for the removal of inorganic compounds.

4.1.3 Characterization of Spirogyra Algal based adsorbent

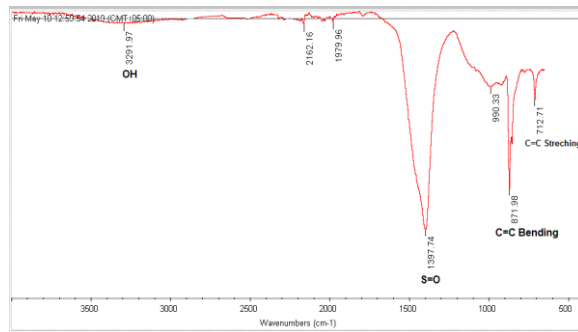


Fig 4.5 Characterization of Spirogyra based adsorbent before contacting with wastewater

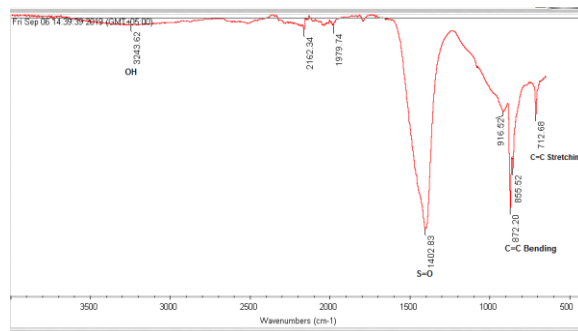


Fig 4.6 Characterization of Spirogyra based adsorbent after contacting with wastewater

There variations in wavenumbers of hydroxyl group, Sulphur double bond Oxygen group and Carbon double bond Carbon group present in before and after graphs shown in Fig 4.5 and 4.6 thus shows the interaction between pollutants and adsorbent.

4.2.1 SUNSPACE without Algae

- ❖ Ground water is taken as sample.
- ❖ Contact time between ground water and adsorbent was 20 mins at shaker.
- ❖ Tested at 365 nm.

Table.1

S.NO	Sample	C_i	C_f	EFFICIENCY (n)
1	Sunspace Without Algae	0.104	0.012	88.5 %

In previous study, scientists concluded that adsorbent showed up to 94 % efficiency in removal of methylene blue; this study showed removal efficiency up to 91 %. This difference in efficiency is might because of using natural wastewater as methylene blue solution was prepared synthetically in previous study, of replacement of silica fume with cement, of difference in contact timing between adsorbent and ground water and might because of different environmental conditions.

4.2.2 SUNSPACE without Algae vs SUNSPACE with Oedogonium Algae vs SUNSPACE with Spirogyra Algae

- ❖ Ground water is taken as sample
- ❖ Contact time between ground water and adsorbent was 30 mins at shaker.
- ❖ Tested at 365 nm

Table.2

S:NO	SAMPLE	C_i	C_f	EFFICIENCY (n)
1	ACE WITHOUT ALGAE	0.006	0.006	0 %
2	SUNSPACE With Oedogonium Algae	0.006	0.003	50 %
3	SUNSPACE With Spirogyra Algae	0.006	0.013	-116.67 %

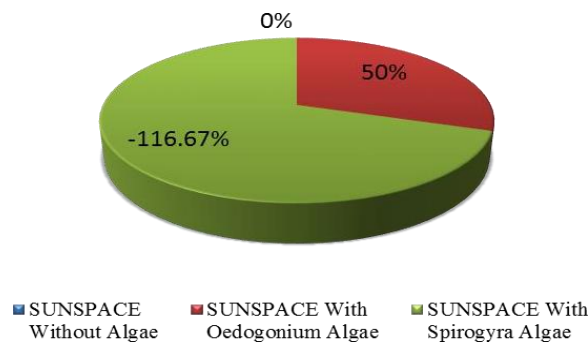


Figure 4.1 Comparison of algal and non-based adsorbents

After every trial fluctuations were observed in the efficiency of adsorbent. In 1st trial non-algal based showed 88.5 % removal efficiency whereas in 2nd trial 0 % removal efficiency was observed. Fluctuations in efficiency might because of improper functioning of UV Spectrophotometer or might because of complex chemistry behind adsorbent. Efficiency of all three prepared adsorbent is compared as shown in figure. Oedogonium specie showed positive effects on adsorbent’s efficiency whereas spirogyra showed opposed effects. Spirogyra showed negative effect might because specie did not used in efficient way or might because of nature of adsorbent.

4.2.3 SUNSPACE without Algae vs SUNSPACE with Oedogonium Algae

- ❖ Ground water is taken as sample.
- ❖ Contact time between ground water and adsorbent was 30 mins at shaker.
- ❖ Tested at 254 nm.

Table.3

S:NO	SAMPLE	C_i	C_f	EFFICIENCY (n)
1	SUNSPACE WITHOUT ALGAE	0.011	0.002	81.82 %
2	SUNSPACE With Oedogonium	0.011	0.001	90.91 %

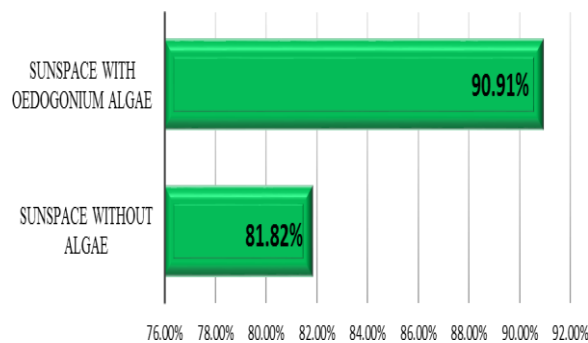


Figure 4.2 Comparison of SUNSPACE with Oedogonium algae and SUNSPACE without algae

As spirogyra showed negative efficiency so spirogyra based adsorbent is kept in side and Oedogonium and non-algal based adsorbent’s efficiency is compared. Oedogonium based adsorbent showed greater removal than non-algal adsorbent as obvious in figure 5.2. As Algae has potential to remove organic matter from water and SUNSPACE has too so efficiency is increased might because of combined potential of Oedogonium and adsorbent. However, after every trial fluctuations in efficiency were observed.

V. CONCLUSION

There is an urgent need of sustainable technique to deal with increasing water pollution. Because of high cost and unsustainability, existing techniques are not feasible for use. Among various water associated issues, organic pollution is concluded as a major threat of this epoch and there is no any suitable technique to remove organic matter from water. Considering all these circumstances, this work brings forward a sustainable and cheap adsorbent that will adsorb organic matter from water up to 91 %. Oedogonium algal specie showed remarkable positive effects on adsorbent’s efficiency whereas Spirogyra algal specie showed negative effects. Constant fluctuations were observed in adsorbent’s efficiency after every single trial. At our best knowledge, reasons of fluctuation could be improper functioning of UV spectrophotometer, Complex nature of adsorbent, Environmental conditions and so forth. However, it is recommended to expert that light must be thrown on this adsorbent. SUNSPACE has remarkable nature to treat water pollution, not only organic matter but it also has potential to remove heavy metal from water and particulate matter from air. If focus will be given

VI. RECOMMENDATIONS

- The focus should be given to this adsorbent; this adsorbent has potential to become leading wastewater treatment among present ones in wide aspects.
- Silica fume must be used in place of cement as silica fume is more beneficial than cement in terms of sustainability.
- More detailed study on above used algal species should be conducted as algae can be used in many other efficient ways.
- Chemistry behind SUNSPACE should be explored by experts.
- In this work SUNSPACE is solely used to tackle with organic matter pollution. However, it can be used to get rid of heavy metals from water and particulate matter from air as well.

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