The reuse of palm tree fiber waste as a solid adsorbent for the removal of methylene blue dye from wastewater

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Outlines

- Introduction
- Aim of The Study
- Materials and Methods
- Results and Discussion
- Conclusion and Recommendations

Hydrosphere

Water represent 70% of the earth

Distribution of the earth's water

Oceans	97.7 %
Ice and Snow	1.9 %
Underground	0.4 %
Lakes	0.009 %
Atmosphere	0.0013 %
Rivers and Streams	0.0002 %

Introduction

The toxicity problem associated with release of dyes into the environment are the main reasons of these worries. Methylene blue (MB) dye is used as coloring in the industries such as cotton, rubber, textile, plastics, silk painting and others.

Introduction

The significant concern due to the adverse effects of dye in various parts of the life cycle.

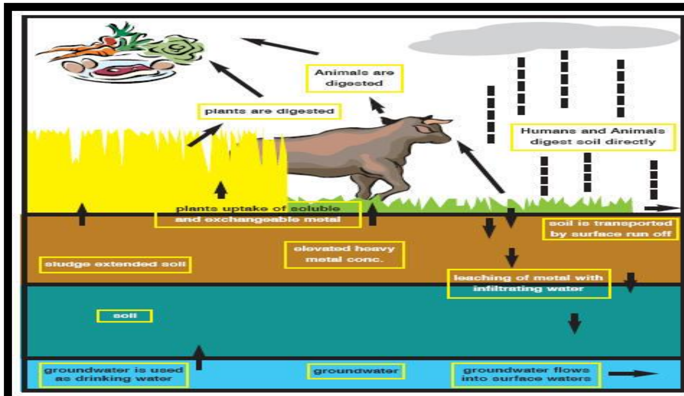
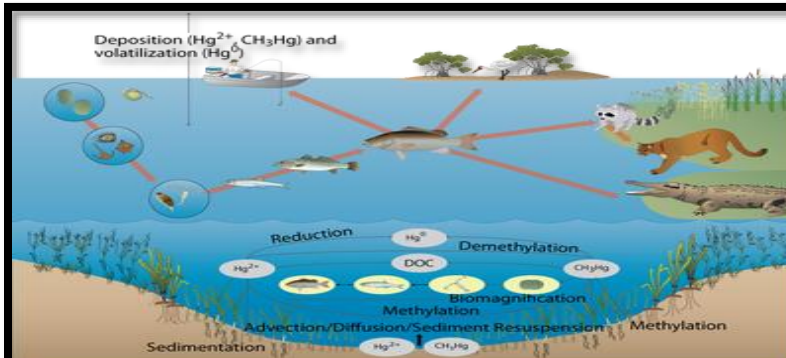


Figure 1: The heavy metal cycle, with heavy metals moving from the environment (pollution) to the human body through the food chain.



Conceptual diagram illustrating mercury biomagnification within the aquatic food chain.
Diagram courtesy of the Integration and Application Network (ian.umces.edu), University of Maryland Center for Environmental Science. Source: Kruczynski, W.L., and P.J. Fletcher (eds.). 2012. Tropical Connections: South Florida's marine environment. IAN Press, University of Maryland Center for Environmental Science, Cambridge, Maryland. 492 pp.

Hazardous of dyes

Humans :

1- eye burn

2- breathing problems

3- nausea

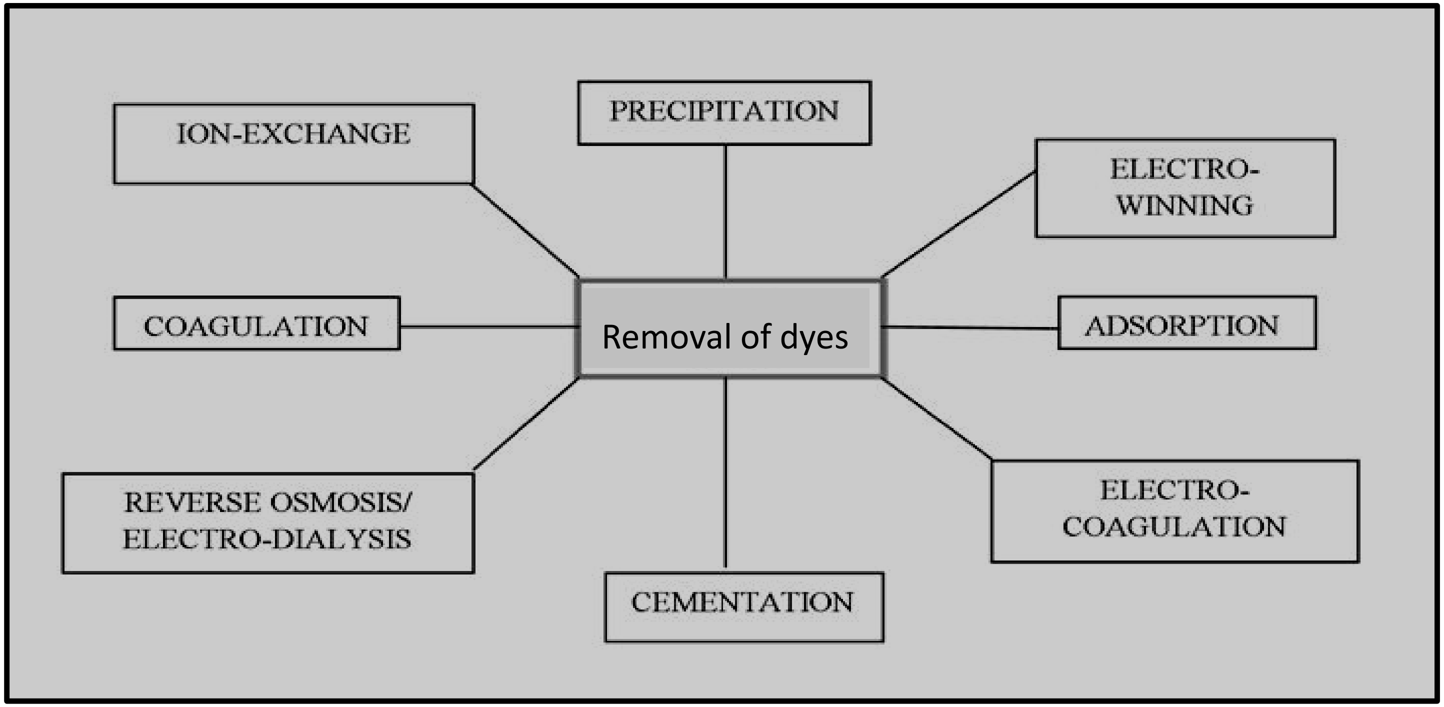
4- vomiting

Prevent negative effects of dyes in waste water

Waste water need for treatment before discharge to receiving water bodies to eliminate any current or potential threats to the public health and environment.

Introduction

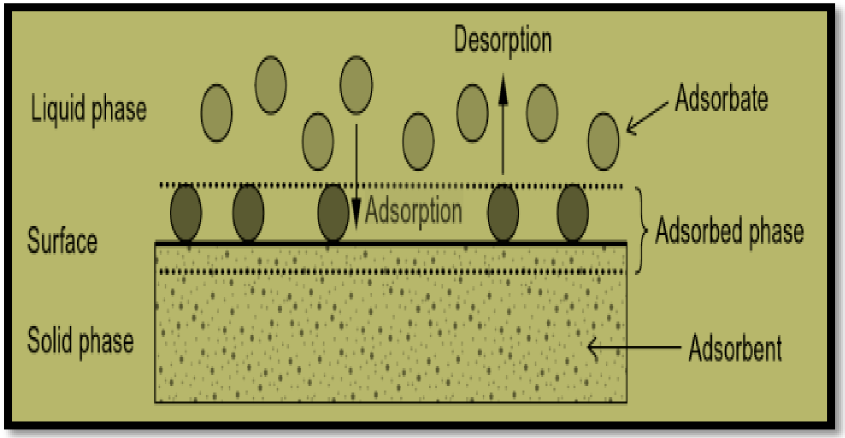
Conventional methods for removal of MB dye from waste water



Introduction

Most useful method is adsorption

Solid phase extraction → liquid phase + solid phase
Liquid solution containing dyes
(adsorbate)
Solid surface containing functional group (adsorbent)



Introduction

Biosorption

biomass material
(sorbent)

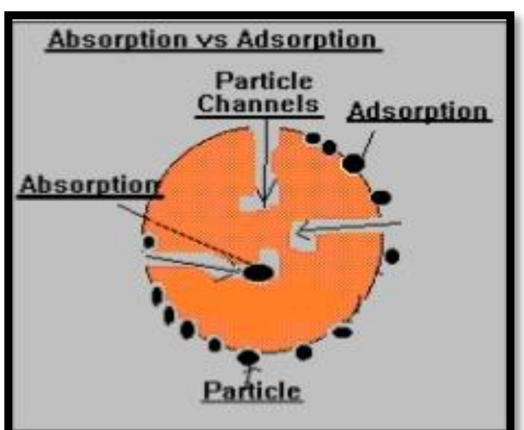
+

Sorption process

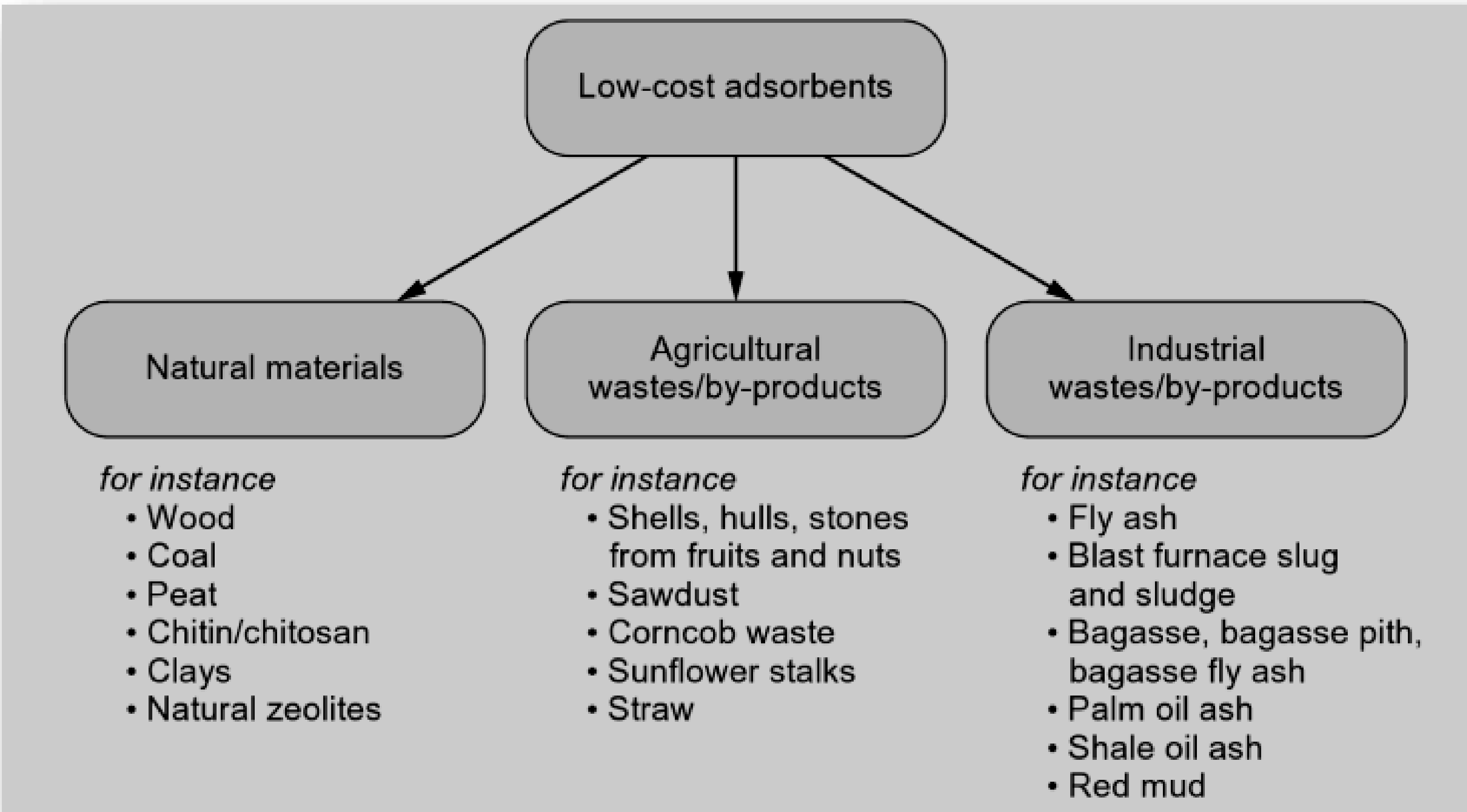
Adsorption
(external surface)

+

Absorption
(internal surface)



Classes of low coast material biosorbent



Worch.E, "Adsorption Technology in Water Treatment: Fundamentals, processes, and Modeling",2012

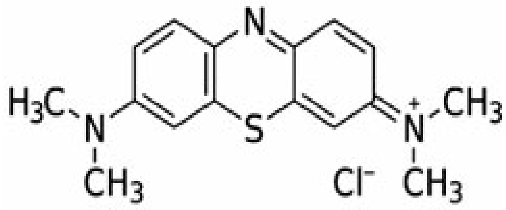
Agricultural biosorbent

Lignocellulosic substances

Composed of high molecular weight compounds with functional groups which binding with dyes by different mechanisms.

Aim of The Study

Palm Tree Fiber (PTF), a residue from date farms and industry was used as a biosorbent for the removal of Methylene blue dye (MB) from contaminated water.



Methylene blue dye

Materials and Methods

❖Adsorbent preparation:

- Palm Tree Fiber was washed with tap water several times finally washed with distilled water.
- Dried at room temperature, grounded using grinder then sieved and stored into plastic bag.

❖ Characterization and Morphology

- FTIR, Fourier transforms infrared absorption spectrometer.
- FESEM, Field Emission Scanning Microscopy/Energy Dispersive X-ray - 20 Kv.

Results and discussion

Characterization studies of Biosorbent material

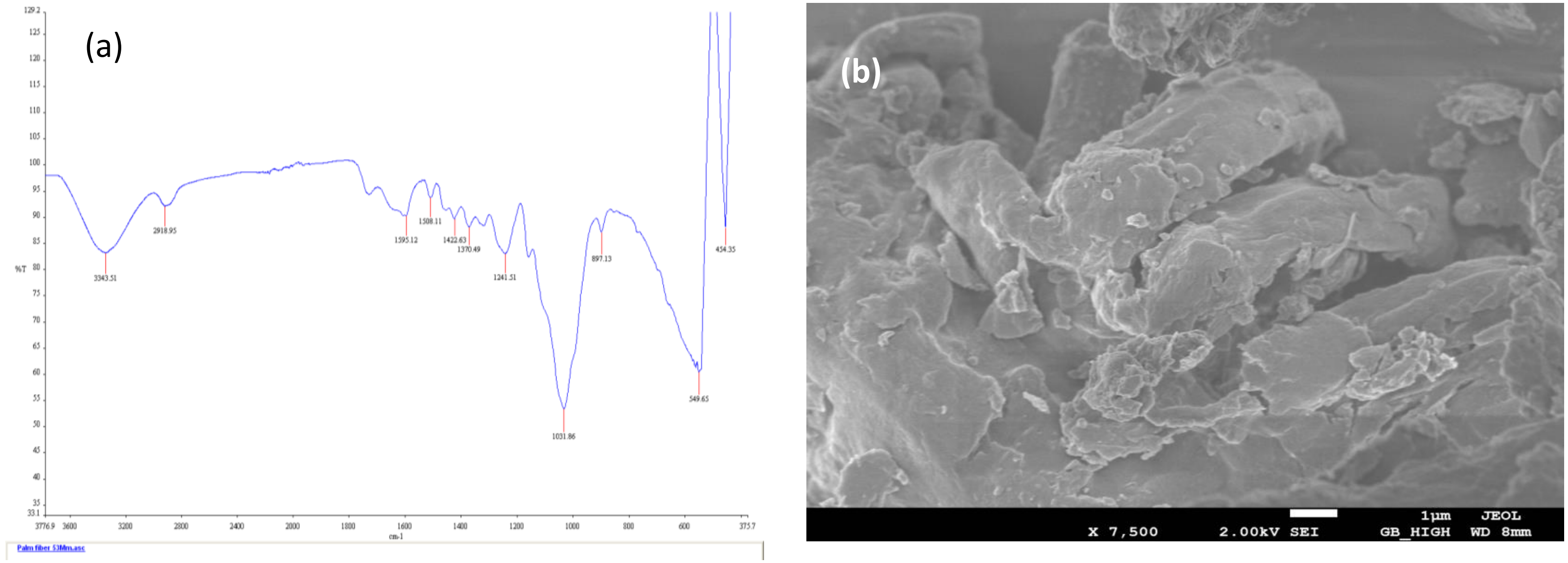
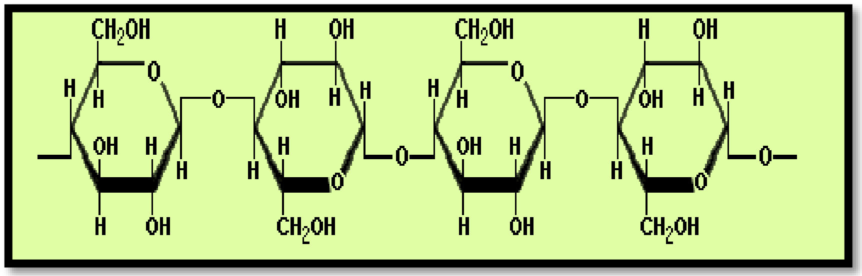


Figure 1: Characterization of PTF (a) IR spectra (b) SEM image amplified 7,500 times.

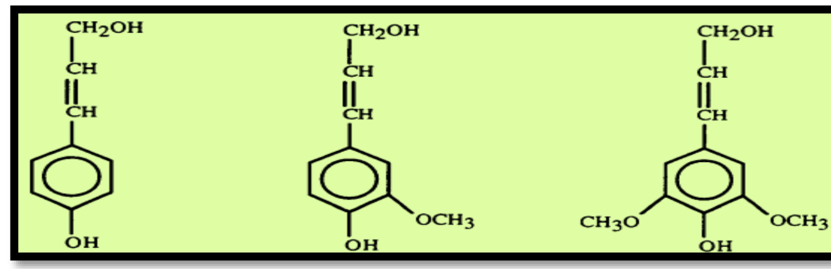
Farooq, Kozinski et al. 2010

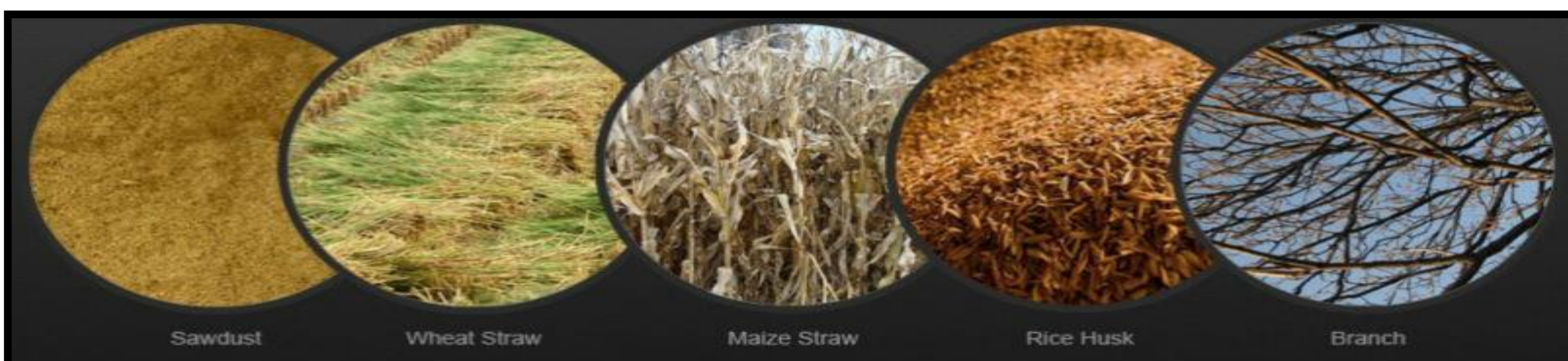
Agricultural residue contain

Cellulose



Lignin





Results and discussion

Characterization studies of Biosorbent material

FTIR spectra of the PTF Fig.1 (a) shows functional groups (carboxylic, hydroxyl, and amine) on the adsorbent's surface, these groups found in the cellulose, lignin or amine (NH_2) and starch of fibrous plants' biomass. These functional groups are empower natural adsorbents to remove dyes in contaminated water by adsorption, ion exchange or complexation.

The SEM showed that the PTF is composed of large overlayered rough irregular particles as it is presented in Fig.1 (b).

Farooq, Kozinski et al. 2010

Materials and Methods

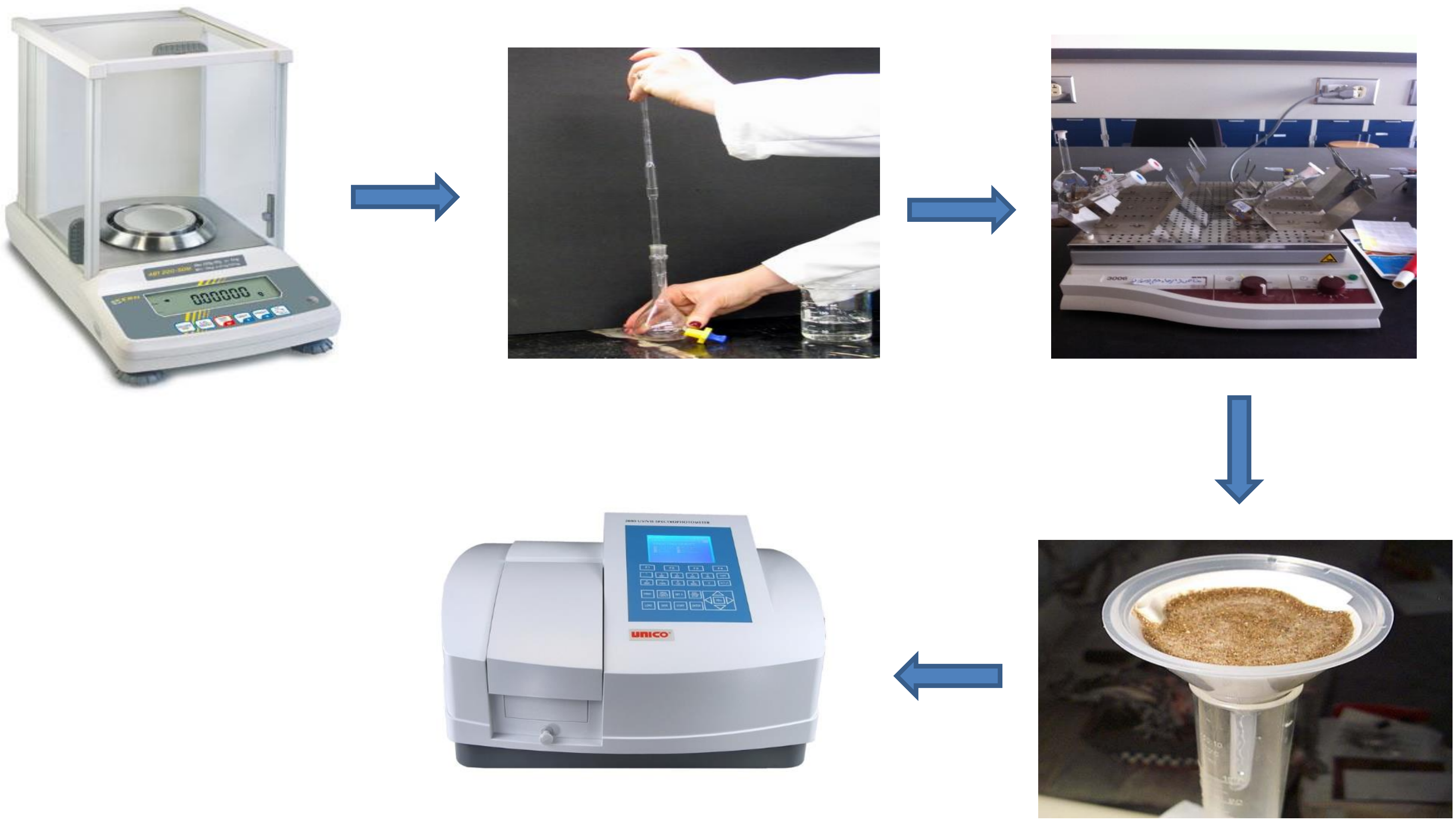
- Study effect of different environmental factor:
  - Adsorbent mass
  - Contact time.
  - pH factor.
  - Temperature.

- kinetic models and isotherms equilibrium were utilized to describe the adsorption process mechanisms.

- Environmental application & Recycling.

Material and Methods

❖**Batch experiment:**



Results and discussion

Effect of adsorbent dose

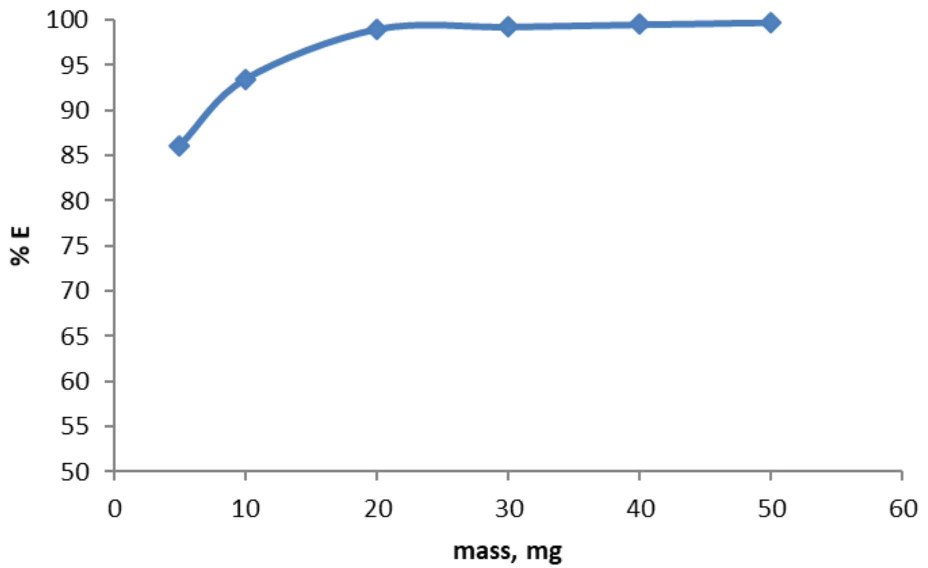


Figure 2: Effect of dosage on the adsorption of MB by PTF removal at (Time = 60 min and Temp = 20 ^{o}C).

Results and discussion

Effect of contact time

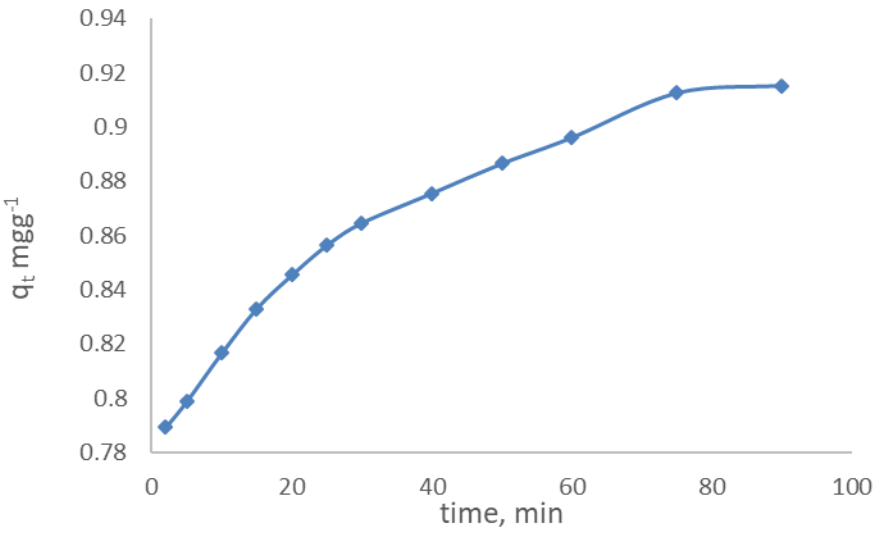


Figure 3: Effect of contact time on the adsorption of MB by PTF removal at (Mass =0.5g and Tem = 20 ^{o}C)

Results and discussion

Effect of pH

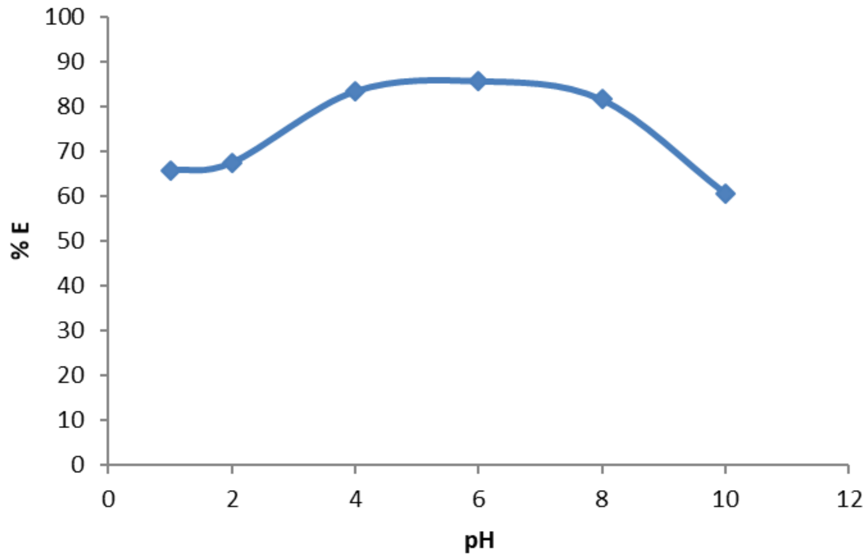


Figure 4: Effect of pH on the Adsorption of MB by PTF at (Mass =0.5g, Time = 60 min and Temp = 20°C)

Results and discussion

- The maximum percentage removal of MB was about 99 %, at the dosage of 20 mg.
- The maximum adsorption capacity was 0.912 mgg^{-1} for MB at 75 min.
- The highest percentage removal was 85.6% at pH 6.

Results and discussion

Effect of temperature

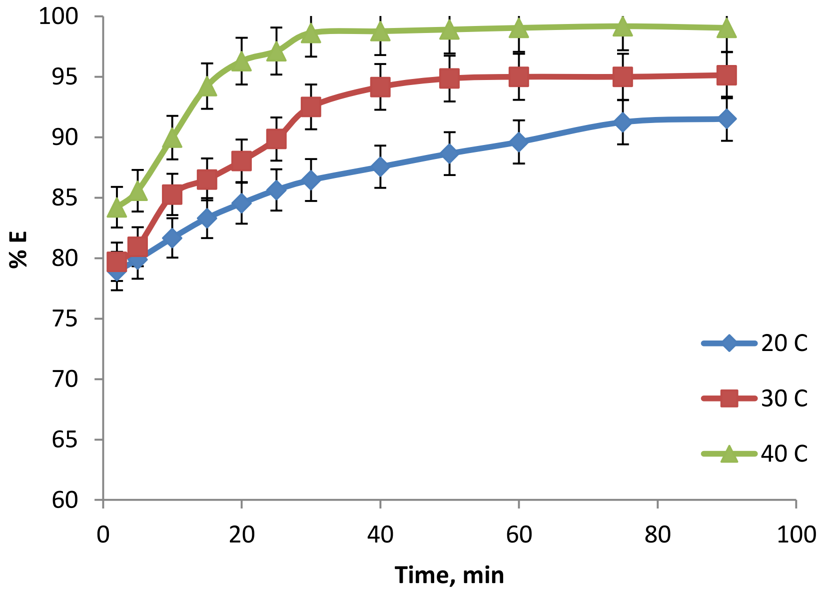


Figure 5: Effect temperature on the Adsorption of MB by PTF at (Mass =0.5g Time = 90 min)

Results and discussion

- The adsorption percentage of MB increased with increasing the contact time and the solution temperature.
- The maximum adsorption percentage was 99% at 40 ^{0}C & 30 min.

Results and discussion

Kinetic studies

1.Pseudo-First Order

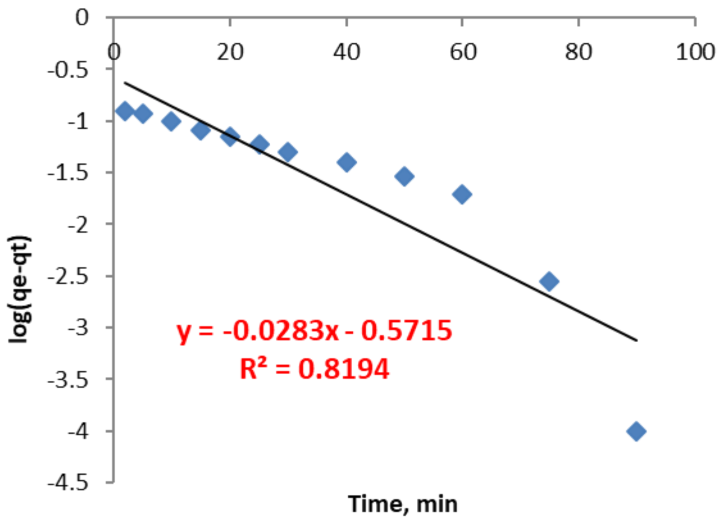


Figure 6: Pseudo-First Order Model for Adsorption of MB on PTF.

2.Pseudo-Second Order

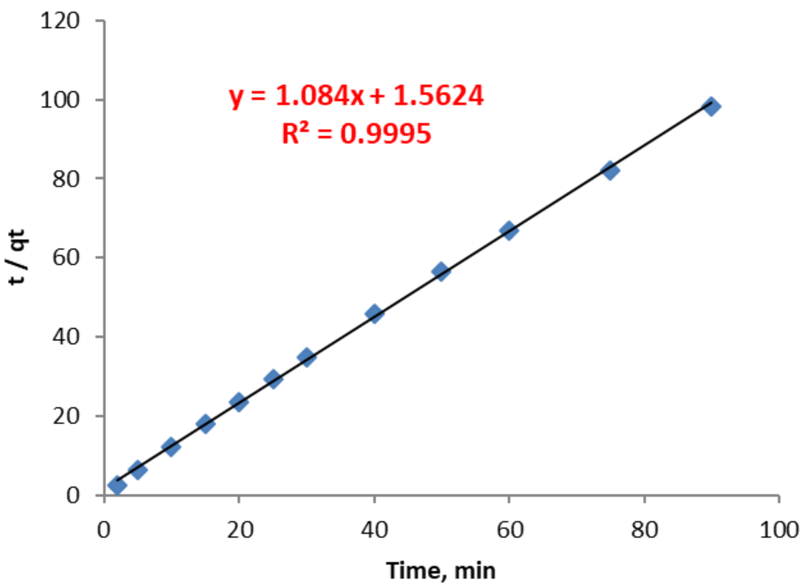


Figure 7: Pseudo-Second Order Model for Adsorption of MB on PTF.

Results and discussion

Table 1 : Pseudo first order and Pseudo second order kinetic parameters for adsorption of MB on PTF

	Pseudo first order				Pseudo second order		
Dye	q_{exp} (mgg^{-1})	q_{cal} (mgg^{-1})	K_1(min^{-1})	R^2	q_{cal} (mgg^{-1})	K_2 (g mg^{-1} min^{-1})	R^2
MB	0.9153	0.2682	-0.0652	0.8194	0.9225	0.7521	0.9995

Results and discussion

- The first-order model did not provide a good fit, even when evaluated for the first 30 min of adsorption, with q_e values being significantly underestimated.
- In the case of pseudo-second order model, a good straight line was obtained with acceptable correlation coefficient ($R^2 > 0.99$) and a good correlation between the theoretical q_e value (0.9225 mgg^{-1}) with experimental one (0.9153 mgg^{-1}).
- This indicates that MB adsorption by PTF can be satisfactorily described by the pseudo-second order model.

Results and discussion

Adsorption isotherm

1. Langmuir isotherm:

Table 2: Langmuir isotherm for adsorption of MB on PTF

Langmuir			
Temp ^{0}C	q_m (mgg^{-1})	K_l (Lmg^{-1})	R^2
20	0.7156	-0.0068	0.9981
30	0.7586	-0.0191	0.9975
40	0.8264	-0.0069	0.9986

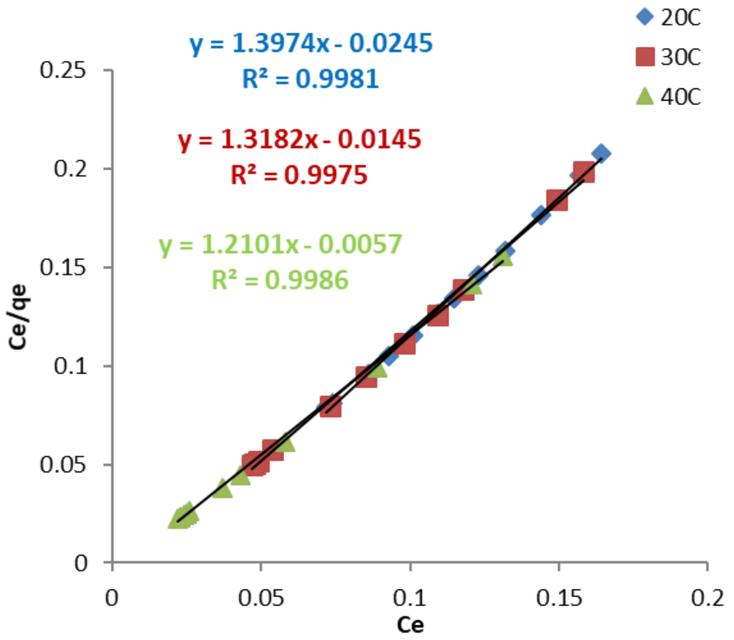


Figure 8: Langmuir isotherm for Adsorption of MB on PTF

Results and discussion

2. Freundlich isotherm :

Table 3: Freundlich parameters isotherm for adsorption of MB on PTF

Freundlich			
Temp ^{0}C	n	K_f (mgg^{-1})	R^2
20	-5.6421	-0.6253	0.9798
30	-7.3779	-0.7029	0.9651
40	-11.6727	-0.8498	0.9499

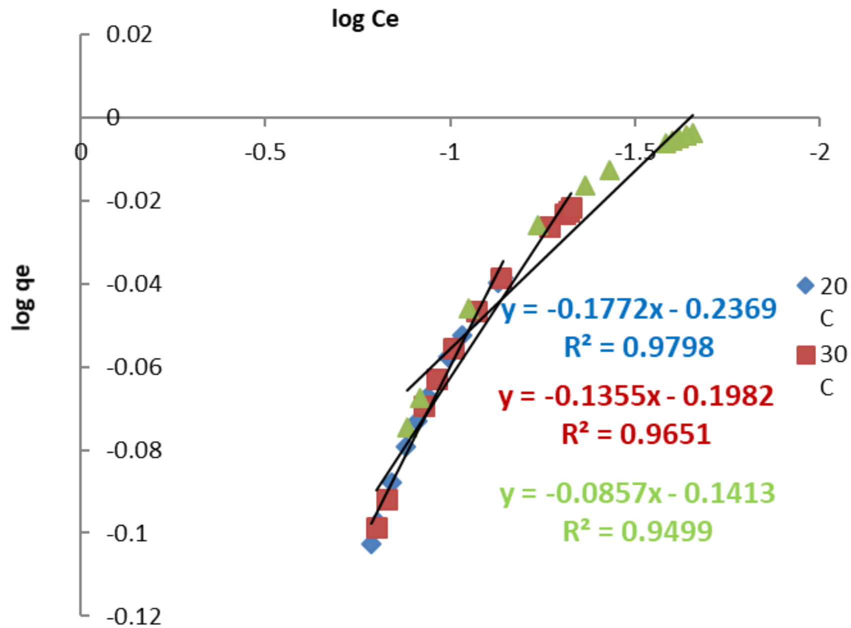


Figure 9: Freundlich isotherm for adsorption of MB on PTF.

Results and discussion

- The adsorption data fitted to the Langmuir and Freundlich isotherm models, indicated that the both isotherm models provides a better fit due to the high R^2 values 0.998 - 0.979 at all different temperature.
- Based on the Langmuir and Freundlich isotherm models, indicated that the adsorption prosses is a monolayer and homogeneous adsorbent over a surface, in the seam time there is a heterogeneous adsorption over independent sites.

Results and discussion

Environmental application

The applicability of **PTF** for the removal of MB dye from sea and tap water was studied, and it was found that high percentage of MB could be removed.

Table 4: Environmental application

Environmental sample	% E	q_e mgg^{-1}
Sea water	99.273	3.971
Tap water	99.510	3.980

Results and discussion

Biomass Regeneration:

The dye recovery was higher in the first cycle (88%) than the second system (73%) (Table 5). The regenerated biomass exhibited a good dye adsorption up to two subsequent cycles.

Table 5: Recycling analyses

Recycling	V ml	mass mg	% E	q_e mgg^{-1}
first	20	10	87.741	0.8774
second	10	5	72.654	0.7265

Conclusion

The results presented in this study indicate that PTF presents great potential as an inexpensive and easily available alternative adsorbent for the removal of dyes in wastewater treatments.

Recommendation

For a future research, modification of PTF surface to increase the efficiency of adsorption capacity and scaled up to applied into industrial field.


Thank You!