



## Removal of Pb<sup>2+</sup> Ion from Industrial Wastewater by New Efficient Biosorbents of Oyster Plant (*Tradescantia spathacea* Steam) and Negkassar Leaf (*Mammea siamensis* T. Anderson)

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### ABSTRACT

This work, low-cost biosorbents were prepared from Oyster plant (OP) and Negkassar leaf (NL) for lead (Pb<sup>2+</sup>) removal. The chemical structures of sorbents were characterized by FT-IR and elemental analyzer (CHN). All experiments were conducted in a batch system. The pH (2-7) of a solution, contact time (15-180 min), the dosage of biosorbent (0.25-3.00 gdm<sup>-3</sup>) and the initial metal concentration (2-75 mg dm<sup>-3</sup>) were optimized. The adsorption kinetic of Pb<sup>2+</sup> on sorbents was performed using pseudo-first-order and pseudo-second-order model. Results are good agreement with pseudo-second-order, which described that the mechanism is controlled by chemical adsorption. The adsorption process was examined by Langmuir and Freundlich isotherm. The Langmuir isotherm gave a better fit than the Freundlich isotherm. It can be implied that the single layer sorption of Pb<sup>2+</sup> occurs on the sorbent surface. The maximum adsorption capacity ( $q_{max}$ ) of Pb<sup>2+</sup> on OP and NL is 161.29 and 104.17 mg g<sup>-1</sup>, respectively. In addition, the effective sorbent of OP and NL can be applied to remove Pb<sup>2+</sup> from wastewater samples.

**Keywords:** Pb<sup>2+</sup> removal, biosorption, oyster plant, negkassar leaf

### 1. INTRODUCTION

Wastewater is often contaminated hazardous heavy metals such as zinc, nickel, cadmium, iron, mercury, arsenic, and chromium. Among metals, lead (Pb) is a toxic heavy metal and it is normally used as a raw material in many industries such as a battery, plating, and electronics. Accumulation of Pb in the organism body can affect multiple systems e.g. blood system, and nervous

system. Therefore, the wastewater treatment or Pb content reducing is necessary. The common treatment processes for heavy metal such as chemical precipitation, ion-exchange method, electrochemical methods, membrane filter, and adsorption [1-4] have been used. However, adsorption is considered as a high efficiency method and low operating cost. Most of the adsorbents

are natural biosorbents that are inexpensive and environment-friendly.

Numerous researches have reported the effectiveness of the biosorbent from plants as bio-adsorption. Biomass is derived from different parts of the plant such as seeds [5-6], leaf [7-8], root [9] and peel [10-11]. In this work, the leaf of Oyster and Negkassar were selected as a sorbent because they are excessively growing and abundant plants materials, which commonly found in Asia. Few literature studies have been reported the use of Oyster and Negkassara as an herbal medicine in Viet Nam and Oyster is used as a functional food for relieving cough and bleeding symptoms [12]. In Thailand, Negkassar flowers are commonly used for cancer prevention, heart tonic and reducing of fever [13]. The main chemical structure of Oyster and Nagkassar are carboxyl (-COOH), hydroxyl (-OH) and ethers (-O-) [14-15]. Moreover, there is no any literature on the use of Oyster and Negkassar for biosorption. The structures of leaf are cellulose, hemi-cellulose and lignin that enrich with functional groups such as hydroxyl groups, carboxyl, alcohols and ester [14-15]. These groups can be used to remove metal ions from the solution.

The main aim of this research is to offer the new effective adsorbent of Oyster plant (OP) and Nagkassar leaf (NL) for  $Pb^{2+}$  removal from industrial wastewater. The FT-IR was used to characterize the functional groups of OP and NL sorbents. Factors, affect the adsorption of biosorption, such as pH, contact time, biosorbent dosage and initial  $Pb^{2+}$  concentration were investigated. Finally, the OP and NL sorbent were applied to adsorb  $Pb^{2+}$  in wastewater samples.

## 2. MATERIALS AND METHODS

### 2.1 Metal Solution Preparation

All of the reagents were analytical grade. The metal ion solution was prepared by diluting a  $1,000 \text{ mg dm}^{-3}$  of  $PbNO_3$  solution (AAS grade, Merck) with deionized water. Solutions of NaOH ( $0.5 \text{ mol dm}^{-3}$ ) and HCl ( $0.5 \text{ mol dm}^{-3}$ ) were used to adjust the pH of solutions.

### 2.2 Adsorbents Preparation

Oyster plant (OP) and Negkassar leaf (NL) were washed by using deionized water and dried in the oven at  $60^\circ\text{C}$  for 24 hr. The dried biosorbents were grinded by blender. The powder of OP and NL was washed with deionized water again to remove a pigment and all contaminants and dried in the oven at  $60^\circ\text{C}$  for 24 hr. Then, these powder were sieved to select the particle size between  $125\text{-}150 \mu\text{m}$  and used as adsorbents for this work and the dried sorbents obtained were stored in a desiccator.

### 2.3 Biosorbents Characterization

The functional groups of the OP and NL sorbents were characterized by Fourier transform infrared spectroscopy (FTIR) using Spectrum 100 FT-IR spectrometer.

The C H N content of the OP and NL sorbents were determined by C H N analyzer using Perkin-Elmer 2400 Series CHNS/O analyzer.

### 2.4 The Point of Zero Charge of Sorbents Surface

The point of zero charge ( $pH_{pzc}$ ) of OP and NL was determined by Hafshejani *et al.* [7]. The  $50 \text{ cm}^3$  of  $0.01 \text{ mol dm}^{-3}$  NaCl solution was used and the initial pH values (pH) were adjusted from 1-10 using  $0.5 \text{ mol dm}^{-3}$  HCl and  $0.5 \text{ mol dm}^{-3}$  NaOH. Then, 0.1 g of each sorbent was added to each initial solution and the mixtures were shaken for 90 min at room temperature (200 rpm). The suspensions were filtered

through a filter paper and the final pH values ( $\text{pH}_f$ ) of each solution were measured ( $\text{pH}_i$ ). The  $\Delta\text{pH}$  ( $\text{pH}_i - \text{pH}_f$ ) was plotted against the  $\text{pH}_i$  and at the point of the intersection on the curve with abscissa is called the point of zero charge.

## 2.5 Adsorption Experiments

All of the adsorption experiments were tested in batch system. Each biosorbent was added into the Erlenmeyer flask containing 50 cm<sup>3</sup> of 50 mg dm<sup>-3</sup> Pb<sup>2+</sup> solution. The pH of solutions was adjusted in the range of 2-7 by HCl and NaOH solutions. The optimum pH value of the solution was fixed to study the effect of contact times (15-180 min). The dosage of sorbent was used in the range of 0.25-3.00 g dm<sup>-3</sup> for Pb<sup>2+</sup> adsorption at the optimal pH and contact time for OP and NL sorbent. The effect of the initial Pb<sup>2+</sup> concentration was investigated in the range of 5-100 mg dm<sup>-3</sup>. Each experiment, suspension flasks were shaken at 200 rpm for 90 min at room temperature. The suspension was separated by filter paper and the equilibrium of Pb<sup>2+</sup> concentration was determined by Flame Atomic Absorption Spectrophotometer (FAAS, Thermo Scientific iCE 3000). All experiments were performed in triplicates (n=3).

The efficiency of Pb<sup>2+</sup> removal was determined by the following equation [16]:

$$\text{Percentage of removal} \\ (\text{R}\%) = \frac{(C_0 - C_e)}{C_0} \times 100$$

The metal uptake was determined by the following equation:

$$Q_e = \frac{(C_0 - C_e)}{W} V$$

Where  $Q_e$  is the amount of Pb<sup>2+</sup> adsorbed on biosorbents (mg g<sup>-1</sup>),  $C_0$  and  $C_e$  are the

initial and equilibrium of Pb<sup>2+</sup> concentration (mg dm<sup>-3</sup>), respectively,  $W$  is the mass of biosorbent (g),  $V$  is the volume of Pb<sup>2+</sup> solution (dm<sup>3</sup>).

## 2.6 Biosorbents Applications

Water samples were collected nearby industry area where were automobile parts, logistics, automotive paints, a plastics factory in Samutprakarn province, Thailand. They were filtrated through a filter paper to remove suspension. 10 mg dm<sup>-3</sup> of Pb<sup>2+</sup> standard solution was spiked into samples and the pH was adjusted to the optimum pH for sorbents. The samples (50 cm<sup>3</sup>) were shaken at 200 rpm at room temperature and the adsorbents were separated using a filter paper. In order to reduce the organic interferences of the samples and to obtain free metal ions which can be determined by AAS, the filtrated samples were digested in a beaker and heated with a hotplate. The mixtures of the 50 cm<sup>3</sup> of treated water samples and 2.5 cm<sup>3</sup> of conc. HNO<sub>3</sub> was transferred into a flask and slowly heated until the solution was clear. Digested samples were filtrated by a paper filter and the concentration of Pb<sup>2+</sup> was analyzed by FAAS [17].

## 3. RESULTS AND DISCUSSION

### 3.1 Characterization of Biosorbents

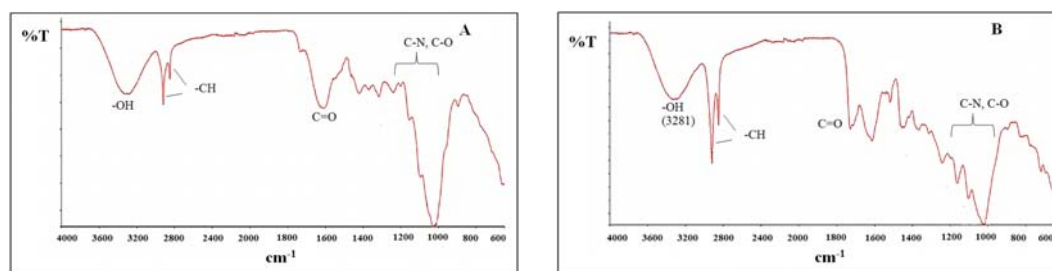
Functional groups of Oyster plant and Negkassar leaf were characterized by Fourier transform infrared spectroscopy (FT-IR) in the range of 4000-400 cm<sup>-1</sup>. The FT-IR spectrums are shown in Figure 1. There are various functional groups on the surface of sorbents. The band at 3333 cm<sup>-1</sup> is the broad band of hydroxyl group (O-H). The strong stretching peak at 2920 cm<sup>-1</sup> and the medium stretching peak at 2853 cm<sup>-1</sup> are -CH symmetric and asymmetric stretching vibration, respectively. The strong stretching

peak at  $1734\text{ cm}^{-1}$  of Oyster plant and at  $1726\text{ cm}^{-1}$  of Negkassar leaf are C = O bonds of carboxylic acid or ester. Many peaks in the range of  $1030\text{--}1230\text{ cm}^{-1}$  are probably C-N and C-O bond. The IR analyses of the sorbents confirmed the presence of the functional groups which were hydroxyl (-OH) and ethers (-O-) groups in biosorbents presented in cellulose, hemicellulose and lignin.

In addition, the elemental constituents of sorbents were analyzed by using C H N analyzer and shown in Table 1. It can be seen that the OP and NL sorbents have similar

organic components with different ratios of elements. The amounts of C, H, and N in OP are higher than NL sorbent. It can be attributed to the amounts of function group contents such as carboxylic group (-COOH) and -CN in OP sorbent is higher than NL sorbent.

However, both types of biosorbents have a similar characterization of the major functional groups such as hydroxyl, ester, ether, carbonyl, and carboxylic acid group. These functional groups are the important active site for ion-exchange mechanisms between the sorbent and  $\text{Pb}^{2+}$  [18].



**Figure 1.** FT-IR spectrums of Oyster plant (A) and Negkassar leaf (B).

**Table 1.** C H N contents of Oyster plant (OP) and Negkassar leaf (NL).

Biosorbent	Percentage (%)		
	C	H	N
Oyster plant	46.35	6.57	2.57
Negkassar leaf	30.65	4.82	2.09

### 3.2 The Point of Zero Charge of Sorbents Surface ( $\text{pH}_{\text{PZC}}$ )

The  $\text{pH}_{\text{PZC}}$  is the pH value that causes the total charge on the adsorbent surface takes a zero value. The  $\text{pH}_{\text{PZC}}$  can be used to describe the possible electrostatic interaction between sorbents surface and the metal ion in solution. At the pH condition is below the  $\text{pH}_{\text{PZC}}$ , the sorbent surface is positive charge and it favors the adsorption of anionic

species. At the pH condition is above the  $\text{pH}_{\text{PZC}}$ , the sorbent surface is negative charge and it favors the adsorption of cationic species [19].

The  $\text{pH}_{\text{PZC}}$  values of OP and NL were found as 8 and 5, respectively. The optimum pH for  $\text{Pb}^{2+}$  in this work for OP and NL adsorption were found to be 3 and 4, respectively and these pH values were lower than the  $\text{pH}_{\text{PZC}}$  ( $\text{pH} < \text{pH}_{\text{PZC}}$ ) (Figure 2A). However, our result was consistent with Petrovic' [20]. From the report of Petrovic' about the  $\text{Pb}^{2+}$  adsorption of the corn silk, it can be discussed that the sorbents surface of OP and NL are positive charge and indicated that the other interactions may be stronger than electrostatic forces involved in the adsorption of  $\text{Pb}^{2+}$ .

### 3.3 Effect of pH

The pH of the solution, one of the important factors, affects the chemical speciation of metal ions in sorbent and the ionization of functional groups on the adsorbent surface. The effect of pH on the adsorption efficiency of the OP and NL is shown in Figure 2(a). For the OP and NL sorbents, the maximum efficiency to adsorb  $Pb^{2+}$  was at pH 3 and pH 4, respectively. The extremely acidic condition, the major functional groups as binding sites in the sorbents are less ionized. Thus, the positive charge of metal ions is not captured by the negative charge of functional groups on sorbents surface. In addition, the active sites on the surface are completed by proton ion ( $H^+$ ) and cannot bind the metal ions [21]. As the pH of the solution was increased, the functional groups become more ionized and deprotonated. Therefore the negative charge of functional groups species on sorbents occurred and it can attract to the positive charge of  $Pb^{2+}$  [16]. The amount of  $Pb^{2+}$  adsorbed onto OP sorbent was higher than NL sorbent. This might be due to the fact that the OP contains more functional groups of carboxyl and hydroxyl, which cause a more ion exchange mechanism of  $Pb^{2+}$  into the sorption site.

### 3.4 Effect of Contact Time

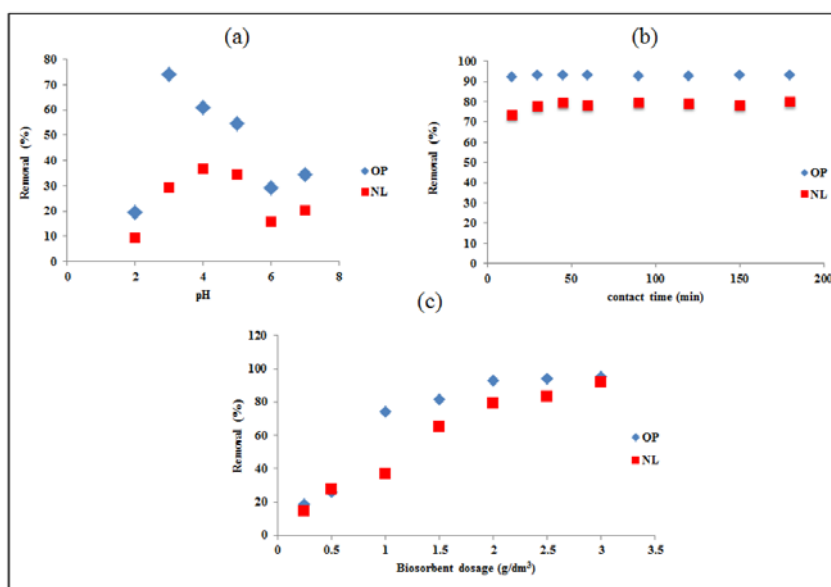
The effect of contact time on the efficiency of  $Pb^{2+}$  removal is an important parameter. The maximum capacity of the adsorbents will occur at the optimal contact time. The suitable contact time of each adsorbent depends on the equilibrium point. The effect of time is shown in Figure 2(b). The contact time was conducted from 15 to 180 min. The fast adsorption rate was at the first 15 min. Both sorbents were highly effective removal. After 15 min, the rate of adsorption slowly increased. It was probably

because of a lot of vacant on the surface at the beginning [20]. Thus, the adsorption rate between the active site and  $Pb^{2+}$  was very fast and high performance. Then, the rate of adsorption was decreased due to fewer amounts of binding sites. To obtain the highest efficiency of  $Pb^{2+}$  removal from wastewater with the less contact time and to ensure that the reaction was reached to the equilibrium state, the equilibrium time of 45 min was selected for OP and NL, in order to future study other parameters.

### 3.5 Effect of Biosorbent Dosage

The surface area of the adsorbent is a crucial factor that affects the ability of metal ion absorption. The increase of the adsorbent amount will increase the number of functional groups (binding sites) on the adsorbent. The surface area can be increased by reducing the size of sorbent particles and increasing the adsorbent dosage. The particle size can affect the capacity to adsorb ions of the sorbent. Adsorbent can increasingly adsorb heavy metal ions by reducing the size. However, Abdolali A. et al. [18] reported that the capacity of the sorbent did not significantly change when the particle size is less than 300  $\mu m$ . So the sorbent size between 125-150  $\mu m$  was used to adsorb  $Pb^{2+}$  in this work.

The effect of the increasing sorbent dosage from 0.25-3.00  $g dm^{-3}$  is presented in Figure 2(c). The OP and NL can dramatically adsorb  $Pb^{2+}$  when the amount of biomass doses was increased from 0.25 to 2  $g dm^{-3}$ . Both types of adsorbents, the effective adsorption was rapidly occurred with the increasing amount of adsorbent and slowly increased when the amount of sorbent above 2  $g dm^{-3}$ . Due to the complex mechanism and overlapping of active sites were happened on the surface of the adsorbent at higher dosage [5,22]. Therefore, the amount of OP and NL to be used in further study was 2.5  $g dm^{-3}$ .



**Figure 2.** Effects of pH (a), contact time (b) and biosorbent dosage (c) on Pb<sup>2+</sup> adsorption of OP and NL.

### 3.6 Biosorption Kinetics

A kinetic motion of Pb<sup>2+</sup> on adsorbent can be explained by Pseudo-first-order and Pseudo-second-order as a kinetic model. These models are used to describe the probable mechanisms involved in the process of the metal ion adsorption on the adsorbents. From Figure 3, the Pseudo-second-order gave the higher regression coefficient than the Pseudo-first-order with the coefficient of determination ( $R^2$ ) closed to 1. The parameter comparisons of kinetic models are derived from the calculation of the following equations.

Pseudo-first-order equation presented by [23]

$$\log (q_e - q_t) = \log q_e - \frac{k_1}{2.303} t \quad (1)$$

Where,  $q_t$  and  $q_e$  are the metal adsorbed at time ( $t$ ) and equilibrium, respectively and  $k_1$  ( $\text{min}^{-1}$ ) is the first-order reaction rate

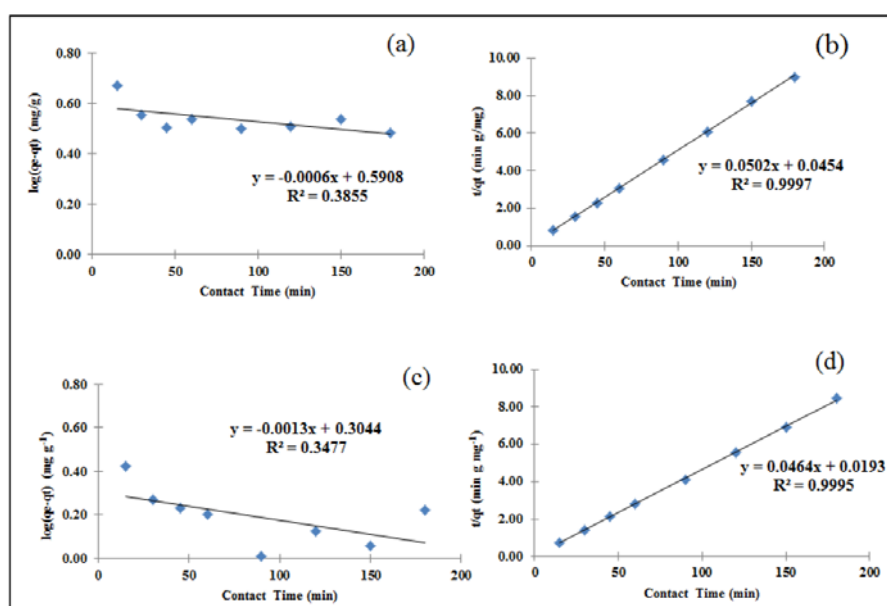
equilibrium constant.

Pseudo-second-order equation presented by

$$\frac{t}{q_t} = \frac{1}{(k_2 q_e^2)} + \frac{t}{q_e} \quad (2)$$

Where,  $k_2$  ( $\text{g mg}^{-1} \text{min}^{-1}$ ) is the second-order reaction rate equilibrium constant.

The adsorption mechanism of Pb<sup>2+</sup> on OP and NL surface results the Pseudo-second-order model because the estimated values (Table 2) between the  $q_e$  of the experiment ( $q_{e,\text{exp}}$ ) and the  $q_e$  of the calculation ( $q_{e,\text{cal}}$ ) are similar. This model assumed that the kinetic of adsorption process is controlled by chemical adsorption which involves covalent electron interaction (covalent bond) between the adsorbent surface and metal ion, or electron transfer between the sorbents and metal ion [24].



**Figure 3.** Pseudo-first-order (a, c) and Pseudo-second-order (b, d) for  $\text{Pb}^{2+}$  adsorption on OP (a, b) and NL as biosorbents (c, d).

**Table 2.** The kinetic constants for  $\text{Pb}^{2+}$  biosorption on OP and NL as biosorbents.

Biosorbent	$q_{e \text{ exp}}$ ( $\text{mg g}^{-1}$ )	Parameter					
		Pseudo-first-order			Pseudo-second-order		
		$q_{e \text{ cal}}$	$k_1$	$R^2$	$q_{e \text{ cal}}$	$k_2$	$R^2$
OP	24.23	1.04	0.000318	0.051	23.26	0.20544	1.000
NL	23.02	3.89	0.001426	0.385	20.00	0.05556	0.999

### 3.7 Effect of the Initial Concentration of $\text{Pb}^{2+}$ and Biosorption Isotherms

The biosorption isotherms were obtained by changing the initial  $\text{Pb}^{2+}$  concentration from 2 to 75  $\text{mg dm}^{-3}$ . The relationship between the amounts of  $\text{Pb}^{2+}$  per unit mass of sorbent ( $q_e$ ) versus the final concentrations of  $\text{Pb}^{2+}$  in the solution at equilibrium ( $C_e$ ) was plotted to find the suitably isotherms. The relation between adsorption characteristic of the  $\text{Pb}^{2+}$  and the adsorption isotherms is related to a straight line of the correlation coefficient ( $R^2$ ), when the condition of  $R^2$  approaches to 1.

In this work, the Langmuir and Freundlich isotherm models are used to

describe the adsorption characteristics of metal ions on the biosorbent.

The Langmuir isotherm equation [23] is given by

$$\frac{t}{q_e} = \frac{1}{q_{\text{max}}} + \frac{1}{K_L q_{\text{max}}} \frac{t}{C_e}$$

In addition, Langmuir isotherm model can be described by the separation factor or equilibrium parameter ( $R_L$ ) [25]. The  $R_L$  value indicates the favorability of adsorption isotherm, unfavorable if  $R_L > 1$ , linear if  $R_L = 1$ , irreversible if  $R_L = 0$  and if the  $R_L$  values between 0 and 1 represent favorable adsorption of metal ions.

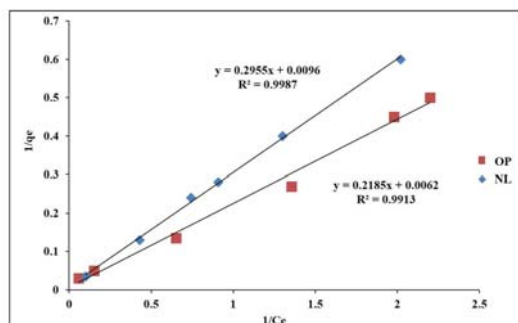
$$R_L = \frac{1}{1 + K_L C_0'}$$

Where  $q_e$  is the amount of  $Pb^{2+}$  adsorbed at equilibrium ( $mg\ g^{-1}$ ),  $q_{max}$  is the maximum of adsorbed  $Pb^{2+}$  on sorbent in the monolayer sorption ( $mg\ g^{-1}$ ),  $K_L$  is Langmuir constant ( $dm^3\ mg^{-1}$ ),  $C_e$  is the equilibrium of  $Pb^{2+}$  concentration ( $mg\ dm^{-3}$ ) and  $C_0'$  is the highest initial concentration

The Freundlich isotherm equation is given by

$$\log q_e = \log K_F + \frac{1}{n} \log C_e$$

Where  $q_e$  is the adsorbed amount of  $Pb^{2+}$  at equilibrium ( $mg\ g^{-1}$ ),  $K_F$  is The Freundlich constant ( $mg\ g^{-1}$ ),  $C_e$  is the equilibrium of  $Pb^{2+}$  concentration ( $mg\ dm^{-3}$ ) and  $n$  represents the heterogeneity.



**Figure 4.** Langmuir adsorption isotherm of  $Pb^{2+}$  on the OP and NL biosorbents.

The obtained results data from Langmuir and Freundlich isotherm equations are shown in Table 3. It can be seen that, the correlation coefficient ( $R^2$ ) from the Langmuir model is better than Freundlich model (Figure 4). The obtained  $R_L$  values ( $0 < R_L < 1$ ) indicate the favorable adsorption of  $Pb^{2+}$ . The adsorption process of  $Pb^{2+}$  on OP and NL can be described by Langmuir isotherm. The adsorbed metal ions are formed a single layer onto biosorption surface with a certain position on the surface [26]. The maximum adsorption capacity ( $q_{max}$ ) of OP and NL are 161.29 and 104.17, respectively. The  $q_{max}$  of this work were compared with the literature data in Table 4. The  $Q_{max}$  of OP sorbent was higher than NL sorbent for  $Pb^{2+}$  removal. The reason is probably the main functional group (-OH, -COOH and -CN) contents in the structure of OP is higher than in NL. Therefore, the OP has more metal-binding active sites and more negative surface, which enhances the retention of  $Pb^{2+}$  onto the surface. However, the OP and NL sorbents compare well with literature research for other biosorbents.

**Table 3.** The adsorption isotherm parameters.

Type of Biosorbent	Adsorption isotherm model parameters for $Pb^{2+}$						
	Langmuir				Freundlich		
	$R^2$	$q_{max}$	$K_L$	$R_L$	$R^2$	$K_f$	$n$
OP	0.9913	161.29	0.0284	0.3195	0.8799	3.0240	0.9037
NL	0.9987	104.17	0.0325	0.2909	0.8774	0.6646	-2.4480



**Table 4.** The maximum capacity of different biomasses for Pb<sup>2+</sup> adsorption from aqueous solutions.

Biomass	q <sub>max</sub> (mg g <sup>-1</sup> )	Ref.
Marula seed husk	20.00	[5]
Cedar leaf	7.23	[7]
Raw con silk	90.00	[20]
Solanum melongena leaf	71.42	[27]
Sugar cane bagasse	86.96	[27]
Orange peel	27.86	[28]
Peanut husk	27.03	[29]
palm tree leaves	72.30	[30]
Rice husk	108.00	[31]
Anadara inaequalvis shell	621.10	[32]
Oyster plant	161.29	This work
Negkassar leaf	104.17	This work

### 3.8 Application of OP and NL Sorbent for Pb<sup>2+</sup> Removal from Real Wastewater Samples

Wastewater samples were treated by biosorbents. The result of Pb<sup>2+</sup> removal is shown in Table 5. Both biomasses can

effectively adsorb Pb<sup>2+</sup>. The efficiency of the adsorption is higher than 90%. Therefore, the OP and NL sorbent can be used as an alternative biosorption to remove of Pb<sup>2+</sup> in the environment.

**Table 5.** The application of Oyster plant and Negkassar leaf for Pb<sup>2+</sup> removal from real wastewater samples.

Sample	Type of sorbent	Concentration of Pb <sup>2+</sup> before the treatment (mg dm <sup>-3</sup> )	Concentration of Pb <sup>2+</sup> after the treatment (mg dm <sup>-3</sup> )	Percentage of Pb <sup>2+</sup> removal (%)
A	OP	10.10	0.769	92.39
	NL	10.10	0.994	90.16
B	OP	10.39	0.735	92.93
	NL	10.39	0.954	90.82
C	OP	10.48	0.720	93.13
	NL	10.48	0.952	90.92
D	OP	10.43	0.675	93.53
	NL	10.43	0.791	93.19

## 4. CONCLUSIONS

This study concentrates on the biosorption of Pb<sup>2+</sup> from industrial wastewater using the locally sourced Oyster plant (OP) and Nagkassar leaf (NL) as

environmental-friendly and low cost biosorbent. The major functional groups of biosorbents including alcohol, ester, ether, carbonyl and carboxylic acid, play an important role in the ion exchange process

with metal ions in solution. The efficiency of  $Pb^{2+}$  adsorption on sorbents depended on pH values, contact time, biomass dosages, and initial  $Pb^{2+}$  concentrations. In the biosorption isotherms, the equilibriums data fit the Pseudo-second-order model better than Pseudo-first-order. In the adsorption isotherms, the results data fit Langmuir model better than Freundlich model. Moreover, the maximum biosorption capacity ( $q_{max}$ ) of OP was higher than NL for  $Pb^{2+}$  adsorption. However, the  $q_{max}$  of OP and NL sorbents compare well with literature research for other biosorbents. We suggest that the main adsorption mechanisms of  $Pb^{2+}$  sorption onto biosorbents are through the specific ion exchange mechanism and chemical adsorption with the certain position of  $Pb^{2+}$  on the surface in a monolayer adsorption. The presented examination of the OP and NL can be applied as adsorbent for  $Pb^{2+}$  removal, because it can successfully and rapidly remove  $Pb^{2+}$  from industrial wastewater samples. In addition, the other heavy metals will investigate in the further.

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