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RESEARCH ARTICLE

LABORATORY BASED STUDIES ON THE BIOPOTENTIAL OF *PONGAMIA GLABRA* BARK POWDER IN PHYTOREMEDIATION OF TANNERY EFFLUENT

Ganesan, N., Samyappan, K. and Saravanan, R.*

Post Graduate and Research Department of Zoology, Dr. Ambedkar Government Arts College, Vyasarpadi, Chennai 600039, Tamil Nadu, India

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ABSTRACT

The study aims to investigate the ability of biological treatment of raw tannery effluent by using *Pongamia glabra* bark powder to decolourize tannery wastewater contaminants in terms of heavy metal removal capacity and efficiency and to check their ability to decolorize and to degrade the toxic chemical components of the tannery effluent at various concentration and pH. This study will undoubtedly provide a clearer understanding of the current state, challenges and probable solutions for bioremediation process of tannery wastewater using phytomaterials for a greener and cleaner environmental clean up.

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INTRODUCTION

Heavy metals are toxic, persistent, carcinogenic and mutagenic in nature. Industrial wastewater is a widely known source for metal pollution in aquatic bodies as well as surface contamination. Tannery effluent is the collection of water which are formed during various stages of processing of leather and collectively called as composite effluent. Chrome tanning uses acids, various solution of chemicals, and salts including chromium sulphate to tan the hides and skins (Silvateam, 2020). Tannery wastes produce serious consequences of fresh water pollution and agricultural lands (Sangita Ingole *et al.*, 2012). Leather industries play a signifcant role in the national economy of many countries, these also create negative impacts on the country's total environment. Tannery effluents are characterized as high-coloured, foul smelling, acidic and alkaline liquor (Essays, 2018). The disposals of these effluents into any surface water affect its quality in diverse ways. The high organic content interferes with the oxygen content of the receiving water. The alkaline and sulphide content jeopardize the aquatic life. Effluent contains hydrogen sulphide gas when mixed with receiving water, then this gas is liberated due to the lowering of pH value. The high concentration and low biodegradability of the pollutants present in tannery effluent is a major cause of serious environmental concern (Saxena *et al.*, 2016). Apart from surface water pollution, groundwaters are also contaminated by chromium (Cr) related industrial activities (Belay, 2010; Swathanthra and Rao, 2014). Biosorption is an eco-friendly, sustainable, rapid and economic process, which increases its wide application.

Corresponding author:** ***Saravanan, R.
Post Graduate and Research Department of Zoology, Dr. Ambedkar Government Arts College, Vyasarpadi, Chennai 600039, Tamil Nadu, India.

Biosorbents are easily available and low cost in nature. Plant biomasses are commonly used as biosorbents for synthetic and industrial release raw wastewater treatment. The adsorbent capacity of metal ion removal varies, depending on the nature of the adsorbent, pH, contact time, particle size, and metal concentrations. Biological treatment may give a suitable means for Cr (VI) removal from wastewater. Alternately, some low-cost agriculture wastes such as chitosan (Yasmeen *et al*., 2016), rice husk (Xavier *et al*., 2013), waste tea leaves (Nur-E-Alam *et al*., 2018), neem leaves (Gopalakrishnan *et al*. 2013), coconut shell, orange peel (Amir *et al*., 2017), banana rachis (Payel and Sarker, 2018), watermelon rind (Stoller *et al*., 2017), pomegranate husk (El Nemr, 2007), sawdust (Prado *et al*., 2010), have adsorption potential to remove Cr from wastewater particularly from tannery effluent released from tanning industries. Bioadsorbents like Jasminum (Santiago and Santhamani, 2010), *Eichhornia craassipes* (Chakrabarty *et al*., 2017), *Cyprus alterifolius, Typha domingensis, Parawaldeckia, Borassus aethiopum* (Tadesse and Seyoum, 2015), *Typha spp*. (Dotro *et al*., 2009), *Polygonum coccineum, Brachiaramutica, Cyprus papyrus* (Kassaye *et al*., 2017), *Hyptis suaveolens* (Sivakumar *et al*. 2016) and *Chrysopogon zizanioides, Cyperus rotundus*, (Bekele, 2018) have potential to remove Cr from tannery soil and wastewater. The current study will provide an insight to check the potential of *Pongamia* bark capacity and its efficiency for biological treatment of chromium present in the tannery effluent. This pilot study will provide information on the conditions that will make them function optimally for the elimination of the toxic components of tannery effluent.

MATERIALS AND METHODS

Collection of Tannery Effluent: Samples were collected from Common Effluent Treatment Plant (CETP) at Pallavaram in Chennai which treats around 3000 m^3/day of wastewater. The effluent was collected at a fixed point when the discharges from all the stages of processing are released together. The samples were collected during the month of June 2019. The raw effluent was collected in different polyethylene containers of 20 litres capacity and stored in dark at room temperature till further use

Collection and processing of *Pongamia glabra* bark: *Pongamia glabra* bark was collected in the study area Chennai, Tamilnadu, India. The raw bark was sun dried for 3 days, dried in hot air oven at 800^0C for six hours. Dried bark was powdered in pulverizer and washed several times with double distilled water to remove solubles, again dried in hot air oven at 600^0C for 8 hours. The powdered bark was sieved (Indian Standard Sieve) and various fractions of adsorbent was separately stored in air tight container. Adsorbent (plant material) of 5 g/100 ml was used for 24 hours with each aqueous solution.

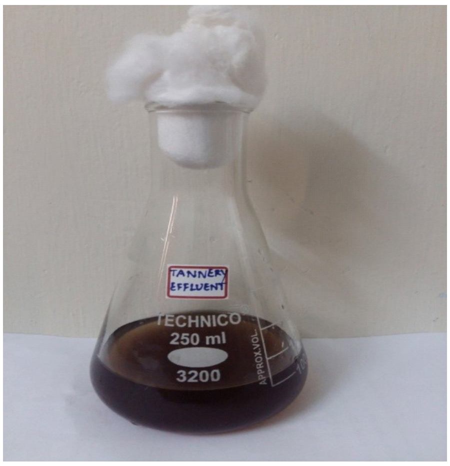
Biodegradation studies of tannery effluent at different concentrations/pH by *Pongamia glabra* bark: Each conical flask was supplemented with decreasing concentrations of the tannery effluent (100 %, 50%, 25%, 12.5% and 6.25%) and incubated at 37 $\pm$ 2^0 C for 24 hrs. *Pongamia glabra* bark of 5 g were introduced in the conical flasks and were incubated at 37 $\pm$ 2^0 C for 24 hrs. After incubation the solution was centrifuged at 5000 rpm for 10 min. Similar the study was carried out at different pH of 6.5, 7, 7.5, 8 and 8.5. The optical density (OD) was taken at the 550 nm wavelength at the initial and final point of the experiment. Percentage decolourization at different concentrations and at various pH was calculated by the using the following formula:-

$$\text{Percentage (\%) decolourization} = \frac{\text{Initial O.D.} - \text{Final O.D.}}{\text{Initial O.D.}} \times 100$$

RESULTS

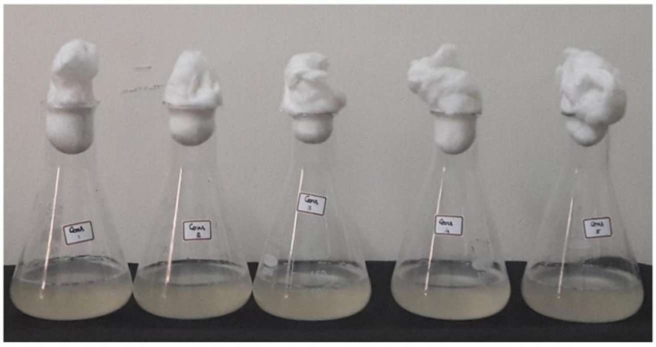
Pongamia glabra bark powdered material showed 60.46% decolorization at 12.5% of tannery effluent concentration, whereas various other concentrations showed a consistent decline in decolorization activity (Table 1; Fig 1). Percentage decolorization of tannery effluent by *Pongamia glabra* bark powder was found to vary with concentration (100%, 50%, 25%,12.5% and 6.25%) when studied up to 24 hr. The results were remarkable at 12.5% tannery effluent concentration treated with *Pongamia glabra* bark Final values expressed as % decolourisation; Bold numerical indicates concentration with maximum % decolourisation.

Decolourization Studies of Tannery Effluent Using *Pongamia glabra*



Control- Untreated tannery effluent sample

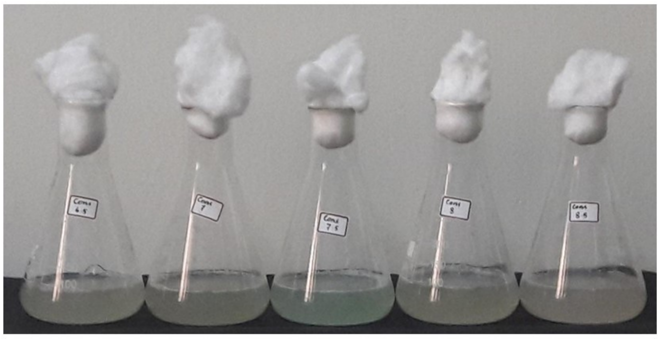
Fig. 1: Decolorization of tannery effluent at various concentrations by *Pongamia glabra*



A B C D E

Concentration of tannery effluent - a.100% b.50% c. 25% d.12.5% e.6.25%

Fig. 1. Decolorization of tannery effluent at various concentrations by *Pongamia glabra*



A B C D E

pH range – a. 6.5 b.7.0 c.7.5 d.8 e.8.5

Fig. 2. Decolorization of tannery effluent at various pH by *Pongamia glabra*

The effect of pH on decolourization of tannery effluent by bark powder of *Pongamia glabra* was studied at five different pH (6.5, 7, 7.5, 8 and 8.5) with an effluent concentration of 50%. At pH 7.5 their was maximum decolourisation (Table 2; Fig 2). Final values expressed as % decolourisation; Bold numerical indicates pH with maximum % decolourisation

DISCUSSION

With rapid industrialization, the environmental hazards posed by heavy metals are becoming more serious (Vimala *et al*., 2020). Heavy metal contamination is a significant environmental issue and its remediation process remains a major problem. Heavy metals from wastewater must be remedied for environmental protection, which necessitates the use of efficient, environmentally sustainable and cost-effective materials. The wastewater treatment technologies used should be cost effective, have a short processing period, with low environmental impact (Abdollahi *et al*., 2018). In present concentration studies on the process of decolourisation the results were remarkable at 12.5% tannery effluent concentration when treated with the *Pongamia glabra* bark powder. Plant materials constitute cellulosic content that is efficient in heavy metal ion biosorption. Metal binding mechanisms are important factors in this process, some function groups may be involved in binding of metal ions and improve adsorbent property, such as ketones, aromatic amines, carboxylic group, ethers, aldehydes and phenolic groups (Demirbas, 2008).

Studies on biosorption using plant material for heavy metal removal include biosorbents such as seed (Gutha *et al*., 2011; Hadi *et al*., 2011; Rao and Rehman, 2012), leaf (Shafique *et al*., 2012; Reddy *et al*., 2012; Al-Dujaili *et al*., 2012), root (Li *et al*., 2013a, 2013b), bark

Table 1. Decolourisation of tannery effluent at various concentrations by *Pongamia glabra*

S.No.	Plant material	Concentration (%)	Initial O.D	Final O.D	% Decolourisation
1.	***Pongamiaglabra bark***	100	0.175	0.108	38.28
		50	0.189	0.100	47.09
		25	0.192	0.095	50.52
		12.5	0.215	0.085	**60.46**
		6.25	0.072	0.033	54.16

Final values expressed as % decolourisation; Bold numerical indicates concentration with maximum % decolourisation

Table 2. Decolorization of tannery effluent at various pH by *Pongamia glabra*

S.No.	Plant material	pH	Initial O.D	Final O.D	% Decolourisation
1	*Pongamiaglabra bark*	6.5	0.799	0.458	42.67
		7	0.871	0.374	57.06
		7.5	**0.633**	**0.111**	**82.46**
		8	0.592	0.527	10.98
		8.5	0.852	0.565	33.68

Final values expressed as % decolourisation; Bold numerical indicates pH with maximum % decolourisation

(Munagapati *et al*., 2010; Sarin and Pant, 2006; Aoyama *et al*., 2005; Reddy *et al*. 2011), and peel (Owamah, 2014; Feng *et al*., 2011; Saha *et al*., 2013; Huang and Zhu, 2013; Moghadam *et al*., 2013). The biosorption process is dependent on several factors in the treatment process such as pH, temperature, contact time, adsorbent dose and heavy metal concentrations. These are important factors responsible for binding of metal ions in aqueous solutions. In metal binding mechanisms, functional groups enhance the affinity of metal ion and form weak or strong bonds with metal ions. Cellulose, hemicelluloses, lignin and pectin with small amount of protein are also present in plant biomass. These materials help in the binding of heavy metals on the surface of biosorbents. The biosorption capacity increased at higher metal concentration and provides an important driving force to overcome all mass transfer resistance of the metal between the aqueous and solid phases. The efficiency of metal ion binding is highly dependent on the constituents of adsorbent. The outer surface of biomass contains polysaccharides and proteins that offer active sites for binding of metal ions in aqueous media (NurEAlam *et al*., 2020). The pH of the solution plays an important role in adsorption process, it influences the chemistry of metals present in aqueous solution and the concentration of the counter ions on the functional groups of the adsorbent surface. The bark of *Pongamia glabra* proved to provide better results at a pH of 7.5 in the present study with maximum decolurisation capacity of the tannery effluent. It was found that the sorption efficiencies were pH dependent, and the biosorption capacity increased with increasing pH. The improved metal ion adsorption with higher pH was attributable to the increase in the amount of ligands for metal ion bonding. Moreover, at low pH, competition occurs between hydronium and positively charged metal ions, and the metal ions biosorption reduces (Jain *et al*., 2016**).** Chen *et al*. (2010) studied the pH effect on adsorption capacity of Cu(II) using camphora tree leaves. At higher pH, H^+ ion number increased, and more exchangeable cations were available for metal binding capacity. Cu(II) adsorption capacity increased with increasing pH value. Similar reports were observed in corn stalks on chromium removal (Chen *et al*. 2011).

El-Said *et al*. (2011) studied the effect of solution pH (2-8) on the adsorption of metal ion at equilibrium state. They observed that the removal of metal ion increased with increasing pH, the maximum removal occurred at pH 6 for Zn(II). Similar mechanisms may have taken place in the present experimental study. According to Noorjahan *et al*. 2014, highly alkaline water if consumed would affect the mucous membrane and may cause metabolic alkalosis in aquatic animals. In addition, the toxicity of certain substances present in water may be enhanced due to their interaction with high or low levels of pH prevailing which may further be detrimental to aquatic organisms. A near neutral pH for the action of plant materials would be effective in treatment of naturally occurring tannery effluent as observed in this study. Plant-based adsorbents have been successfully used in the biosorption of toxic metal ions from aqueous solutions. These materials are used in the development of environmentally friendly, low cost, efficient and clean technology for wastewater treatment. These plant-based materials are agricultural by-products, which possess high affinity for removal of heavy metal ions and can also be used as bioflocculants (Dhir, 2014 ; Nilanjana Das *et al* ., 2021).

CONCLUSION

The adsorption process contributes significantly to the remediation process due to ease in operation, selectivity for metal ions, wide applicability in pollutant removal and affordability of the method. The adsorbents have the capacity to sequestrate metal ions in single as well as multiple forms. The treatment of materials generally enhances the biosorption properties. Materials are mostly treated by acidic and alkali solutions. The adsorption process is affected by pH, temperature, initial concentration, and particle size. However, biosorbents are mostly employed for metal remediation in industrial wastewater treatment.

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