Benjamin McLellan *Editor*

Sustainable Future for Human Security

Society, Cities and Governance

Springer

Sustainable Future for Human Security

Benjamin McLellan
Editor

Sustainable Future for Human Security

Society, Cities and Governance

Springer

Editor
Benjamin McLellan
Graduate School of Energy Science
Kyoto University
Kyoto, Japan

ISBN 978-981-10-5432-7 ISBN 978-981-10-5433-4 (eBook)
DOI 10.1007/978-981-10-5433-4

Library of Congress Control Number: 2017953415

Printed on acid-free paper

This Springer imprint is published by Springer Nature
The registered company is Springer Nature Singapore Pte Ltd.
The registered company address is: 152 Beach Road, #21-01/04 Gateway East, Singapore 189721, Singapore

Preface

This volume, *Sustainable Future for Human Security: Society, Cities and Governance*, is the first of two in a series discussing a variety of critical issues for a sustainable and secure future for humanity. Sustainability is a systemic concern that can be examined from a variety of perspectives, at various levels of socio-environmental systems and sub-systems. Sustainable development is also a highly contextual concept, with no two societies or environments being exactly identical with regards to both endogenous factors and exogenous influences. It is therefore impossible to make a perfectly comprehensive examination of the topic of sustainability when considering its applications in (or interpretations from) the real world. However, a range of examples from a variety of fields of examination, such as that offered in these two volumes, should help to create an understanding of the broad landscape of sustainability.

This volume specifically presents on topics of governance, buildings and urban development, environmental science and disaster management.

Governance is a vitally important consideration in effectively achieving the goals of society – whether this is social justice and equitable distribution of benefits or achieving environmental goals such as the mitigation of climate change. Examples in this volume cover human rights, regional identity and the expansion of a renewable energy industry.

Cities are widely acknowledged as vital elements of social change and environmental impact mitigation for the future. Populations of most countries around the world are increasingly becoming more urbanized, as people seek out opportunity in the largest markets. The impact of urban form and the performance of individual buildings as well as their combined effect is vital for the comfort and well-being of the urban population, but also has a significant impact on environmental performance – particularly the need for energy usage and the mitigation of emissions. This volume covers various topics on the impact of vegetation, open spaces and technologies for construction and infrastructure.

Socio-environmental science, linking society's needs with environmental impacts and the improvement of both, is a common theme of many of the chapters in this volume. The use and development of well-being indicators and the examination of a variety of technologies for remediation and valorization of waste are presented.

The final section of this volume is particularly important to the concept of human security, focusing on disaster management. While it is considered that climate change may exacerbate certain extreme weather, and therefore present a greater hazard to human societies, the non-climate related disasters – earthquakes and volcanic eruptions for example – are also important. This volume presents a number of disaster types and their social impacts, as well as solutions for monitoring or mitigating risk.

The chapters presented in this volume were developed by authors who presented at the SUSTAIN 2015 conference, and have been reviewed by the conference committee. The editor would like to acknowledge the efforts of the authors, the editorial staff and the Sustain Society for the successful publication of this volume.

Kyoto, Japan Benjamin McLellan

Contents

Chapter 18 The Potential of Cacao Pod Rind Waste (*Theobroma cacao*) to Adsorb Heavy Metal (Pb and Cd) in Water

Anita Dewi Moelyaningrum

Abstract Jember, Indonesia, is one of the districts producing large amounts of cocoa (*Theobroma cacao*) in Indonesia. The main waste of cocoa production is the cacao pod rinds, comprising approximately 75% of the raw product. Cacao pod rind waste, containing ~12.67% pectin, has the potential to adsorb heavy metals. The objective of this study is to analyse the potential benefits of cacao pod rind waste from Jember cacao plantations to adsorb heavy metals such as Pb and Cd in water. This study represents true experimental research using the completely randomized design (CRD) method. There were control group (C) and three treatment groups (T1, T2 and T3 with 100 g/L, 300 g/L and 600 g/L, respectively) with six repetitions. Both parameters (Pb and Cd) were analysed in 24 samples using atomic adsorption spectrophotometry (AAS). The results show that as more cacao pod rind waste is exposed, the volume of water becomes increasingly turbid. Welch's F test showed that there were significant differences in the levels of Pb in the control group (F, 7.125; Sig, 0.002) and three treatment groups (Sig, 0.00; 0.003; 0.002). In regard to Cd, the one-way ANOVA test using LSD post hoc showed that there were significant differences between the control and treatment groups (F, 3.142; Sig, 0.048; Sig 0.048, 0.009, 0.04). Thus, cacao pod rind waste from Jember has the potential to adsorb heavy metals such as Pb and Cd in water. It could contain heavy metal pollution and maintain sustainability of the environment.

18.1 Introduction

Indonesia is the third largest cocoa producer in the world. Cocoa or chocolate production in Indonesia shows significant growth, reaching 3.5% per year. Jember is one of the main districts producing cacao (*Theobroma cacao*), both for domestic

A.D. Moelyaningrum (✉)
Department of Environmental Health and Occupational Health and Safety, Public Health Faculty, University of Jember, Jember, East Java, Indonesia
e-mail: anitamoelyani@gmail.com; anitadm@unej.ac.id

B. McLellan (ed.), *Sustainable Future for Human Security*,
DOI 10.1007/978-981-10-5433-4_18

consumption and for export. Jember potential with 7,660 hectares of cacao plantation producing 7.67 thousand tons of cocoa per year (Jember, Indonesia official website 2012), and also produces a corresponding high amount of pod rind waste. Cacao pod rind (shell) waste comprises up to 75% of the weight of the entire fruit. Unfortunately, most of the cacao pod rind waste is only used as plant fertilizer by piling it at the sides of the cacao plant.

Cacao pod rind waste has the potential to be reused. Cacao pod rind waste contains high levels of pectin, averaging 12.67%. Pectin is almost evenly distributed in the plant fibres, with the higher concentrations in the middle lamella (Conrad 2008). Pectin is a naturally occurring polymer of D-galacturonic acid methyl ester.

Heavy metals are dangerous contaminants that cause either acute or chronic conditions, if they enter the human body. Continuous contact between humans and heavy metals, such as Pb and Cd, will cause a variety of health effects. Heavy metals can cause anaemia, encephalopathy, mental retardation, etc. Pb and Cd are non-essential metals in human physiology, in that they are not needed by the body, but rather represent a very high level of toxicity. Pb and Cd are not biodegradable and their toxicity does diminish over time. Pb and Cd are heavy metals that are widely spread in the environment, in large part, due to the wide use of Pb and Cd in both industrial and household products.

Human activities, intentionally or often unintentionally, emit Pb and Cd into the environment, which can enter the human body and cause toxicity. Many aspects of industrialization, including fertilization, electroplating, mining, printing and fuel, are sources of heavy metal pollution. In addition to industry and fuel, Pb and Cd exposure can also occur from everyday household products that are found all around us. Some household items are also identified as containing Pb, such as paint (Apostoli et al. 2006), batteries, ceramics and cosmetics. Personal hygiene behaviour is related to the prevention of Pb exposure from household appliances. Final waste disposal, which occurs either by the open dumping method or the controlled landfill method in Indonesia, often leads to heavy metal pollution in the environment, such as in soil and water (Widyasari et al. 2012; Moelyaningrum and Pujiati 2015).

As stated earlier, heavy metals are non-biodegradable, persistent toxins in the environment, which can enter the human body. Biosorption is one of the mechanisms responsible for the metal binding capacity of various biological materials, such as pectin in the cacao tree. Biosorption is more advantageous than other methods in containing heavy metal pollution and boosting environmental sustainability, as it is low cost and environmentally friendly. Pectin can serve as an adsorbent via the biosorption process, which demonstrates the ability of biomass to bind heavy metals in solution through steps of metabolic or physiochemical processes (Asraf 2010). The acetylated hydroxyl function on C2/C3 of galacturonosyl in pectin was predicted to bind heavy metals (Dronnet et al. 1996).

Cacao pod rind waste and the widespread Pb and Cd contamination in the environment have prompted researchers to assess the potential of cacao pod rind waste from Jember cacao (local cacao pod rinds), which are rich in pectin, to adsorb and bind heavy metal contamination such as Pb and Cd in water.

18.2 Material and Method

18.2.1 Materials

Cacao pod rind waste, which was sourced in Jember, Indonesia, for use as experimental adsorbent, had the thin husk peeled off. It was then chopped to $1 \times 2\ cm^2$ in size and weighed for each treatment (Fig. 18.1).

The water for this research was collected from a groundwater source near the site of final landfill disposal in Jember, which has been polluted with Pb and Cd from the municipal waste.

18.2.2 Adsorbent Doses

Treatment involved using pectin-rich cacao pod rind waste mixed with 1 L of water containing Pb and Cd contaminants. The immersion time was 48 h. The quantity and quality of the water were both monitored.

The control group used water contaminated by Pb and Cd, but without cacao pod rind waste. Treatment group 1 (T1) contained adsorbent cacao pod rinds in the amount of 100 g/L; treatment group 2 (T2) contained adsorbent cacao pod rinds in the amount of 300 g/L; and treatment group 3 (T3) contained adsorbent cacao pod rinds at the amount of 600 g/L.

18.2.3 Methods

This study employed experimental research with post-test only control group design. In this design, there are two groups each randomly selected; the first group is a control group (C), which is an untreated group, and there are treated groups (T). The method used in this research is completely randomized design, in which the experiments were conducted with three kinds of treatment (TI, T2, T3)

Fig. 18.1 The cacao pod rind waste with thin husk peeled and cut to ~1×2 cm in size (Source author's image)

and a control (C). Repetition and replication of observations and measurements were done in each group six times so that the total sample was 24 samples. Pb and Cd concentrations in the water was analysed by AAS. The concentration data was analysed with SPSS 16, using a distribution normality test, followed by the Welch's F test and the one-way ANOVA test.

Replication and repetition:

$$(r-1)(t-1) \geq 15$$
$$R = r \times t$$

where:

t = treatment (4)
r = sample
R = total replication

18.3 Results and Discussion

18.3.1 Measurement of Water Quality and Quantities in Each Group (Control, Treatment 1, Treatment 2, Treatment 3)

Cacao pod (fruit) has a rough and leathery rind about 2 cm (0.79 in.) to 3 cm (1.2 in.) thick, although this varies with the origin and variety of pod. It is filled with 30–50 seeds that are fairly soft and have a pale lavender to dark brownish purple colour (Cocoa Bean 2015). The cacao pod rind waste that is used does not undergo any treatment, except the thin epidermis or husk is peeled off and the rind is cut to the size of $\pm 1 \times 2$ cm.

In treatment 1 (T1) group, polluted water containing Pb and Cd was exposed to cacao pod rind waste at the level of 100 g/L. There was physical degradation of water quality, which was a little bit turbid, and its colour turned brown compared to the control group. The mean decrease in water volume after 48 h was 68.3 mL (6.83%), while there was no change in odour compared to the control group. In treatment 2 (T2) group, polluted water containing Pb and Cd was exposed to cacao pod rinds at the level of 300 g/L. There was a physical degradation of water quality that was more turbid than that of the T1 group. However, no change in odour quality was discernible. Meanwhile, after 48 h, the mean decrease in water volume was 190 mL (19%). In treatment 3 (T3) group, polluted water containing Pb and Cd was exposed to cacao pod rinds at the level of 600 g/L. The T3 group exhibited the greatest decrease in water volume compared to the other groups, with a mean decrease of 430 mL or 43%. The cacao pod rind waste attained the characteristic of a liquid adsorbent.

Contacting cacao pod rind waste turns the water into a brownish colour that is caused by pectin. Pectin is a substance in the class of heteroside polymers, which is found in many fruit skins. Pectin is a white to light brown, sticky substance that is frequently used in the field of food and nonfood industries as a jelly-forming, thickening and stabilizing agent for certain products (Towle and Christensen 1980).

The volume of raw water contaminated with Pb and Cd also decreased in proportion to the amount of cacao pod rind waste presented during the 48-h observation period. The water became thickened and as a result, the water volume was reduced. The reduction of the water volume shows that the cacao pod rind waste has the potential to absorb water. The average volumes of water after the 48-h observation period are shown in Fig. 18.2, while the physical water quality is shown in Fig. 18.3.

18.3.2 Measurement Result of Contamination Level of Pb and Cd in Each Group (Control, Treatment 1, Treatment 2, Treatment 3)

Clean water and drinking water have water quality standards, which are requirements in terms of human health and safety. The standards are intended to provide protection to the health of Indonesian citizens. Pb and Cd are heavy metals that are commonly present in the environment and are often found in the air, water and soil and thus represent a source of possible exposure to humans. Pb and Cd are heavy metals that are highly toxic to the bodies of living things. The entry mechanisms of heavy metal contamination, such as Pb and Cd, include inhalation via the respiratory tract, ingestion via the digestive tract or absorption through the skin. Because they are nondegradable and thus persistent in the environment, Pb and Cd have a high toxicity even at low levels.

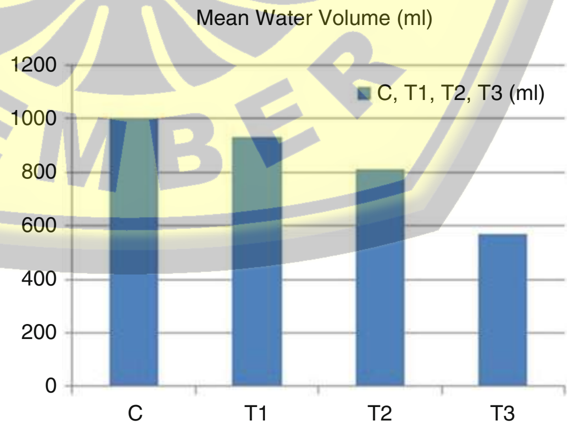

Fig. 18.2 Mean water volume with cacao pod rinds on the C, T1, T2 and T3 groups in the 48-h period

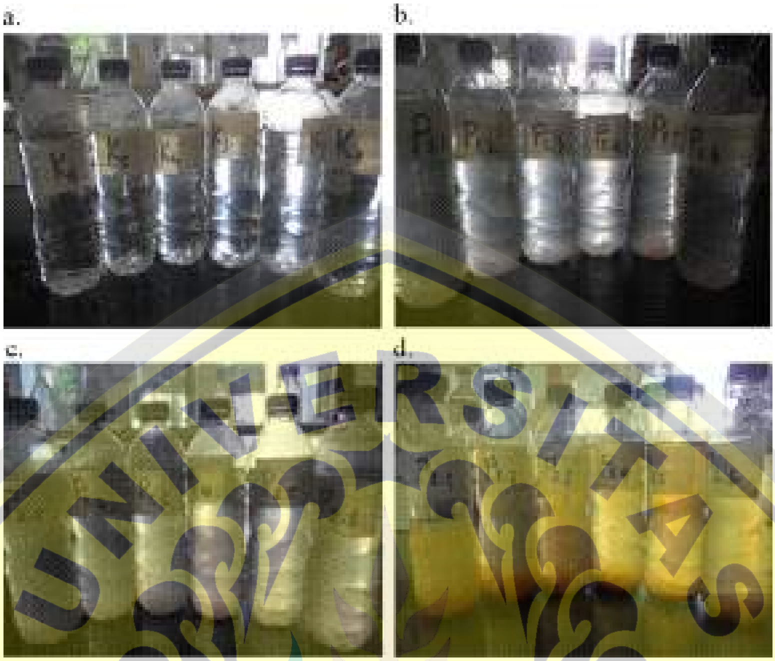

Fig. 18.3 Water quality of the C, T1, T2 and T3 groups (**a**, **b**, **c** and **d**, respectively) in the 48-h period (Source author's image)

Based on the Ministry of Health of Indonesia, Regulation No. 416 of 1990 on water quality standards, it was determined that the drinking water quality standard for Pb is 0.05 mg/L and for Cd is 0.005 mg/L (Ministry of Health of Indonesia, Regulation Number 492 of 2010). A decree by Ministry of Health of Indonesia, Regulation Number 907 of 2002, on drinking water monitoring requirements, states that the minimum standard for Pb in drinking water is 0.01 mg/L and for Cd is 0.003 mg/L (Ministry of Health of Indonesia, Regulation Number 492 of 2010). The regulations were then updated from the Ministry of Health of Indonesia, Regulation No. 492 of 2010, on drinking water quality with a maximum limit of heavy metal contamination for Pb which is 0.01mg/L and for Cd 0.003 mg/L (Ministry of Health of Indonesia, Regulation Number 907 of 2002). The regulations specify this stringent minimum standard for Pb in water because it has been proven that Pb causes toxic effects in the environment, human beings and all living things. The World Health Organization (WHO) maximum permissible limit is 0.01 mg/L Pb and 0.03 mg/L Cd (WHO 2011).

The control group (C) in this study used raw water without treatment with cacao pod rind waste. The levels of Pb in the water were measured in six repetitions using AAS. The control group will be used as a comparison against the three treatment groups. Treatment groups T1, T2 and T3 will undergo exposure to cacao pod rind waste amounting to 100 g/L, 300 g/L and 600 g/L, respectively.

The mean results of six repetition measurements of Pb and Cd contamination levels in the control water were 0.283 mg/L Pb and 0.30 mg/L Cd. The mean results of measurements of the heavy metal concentrations in treatment water 1 (T1) were 0.139 mg/L Pb and 0.154 mg/L Cd. The mean levels in treatment 2 (T2) were 0.165 mg/L Pb and 0.098 mg/L Cd, while the mean levels in treatment 2 (T2) were 0.159 mg/L Pb and 0.14 mg/L Cd. The complete data are shown in Figs. 18.4, 18.5, 18.6 and 18.7.

These results showed that cacao pod rind waste adsorbed Pb and Cd from water in treatment groups T1, T2 and T3. The highest Pb concentrations were recorded in the control group and then decreased with the treatment group of cacao pod rind waste during 48 h. Treatment group 1 (T1) exhibited optimum adsorption of Pb. The highest Cd concentrations were also recorded in the control group and then decreased with increasing amounts of cacao pod rind waste in the treatment groups during 48 h. However, treatment group 2 (T2) exhibited optimum adsorption of Cd.

Biosorption is a complex mechanism, and the effectiveness of biosorption with cacao pod rind waste depends on many factors. Various biological materials affect the biosorption process differently, and the composition of cellulose, hemicelluloses, lignin and pectin is an important factor. Consequently, the cacao pod rind waste that was used in this research was all sourced from the same area. In addition,

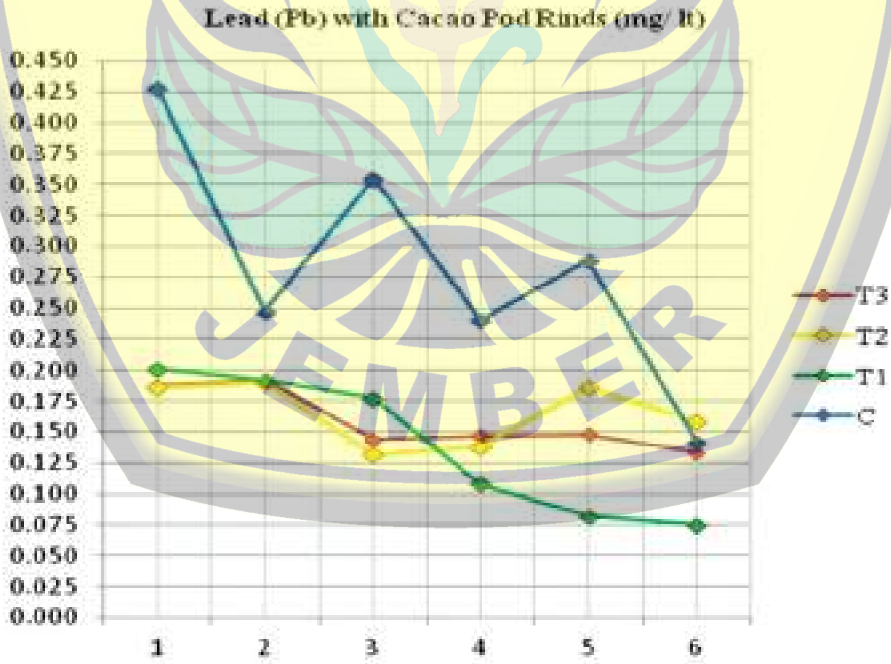

Fig. 18.4 Pb in the C, T1, T2 and T3 groups in the 48-h period

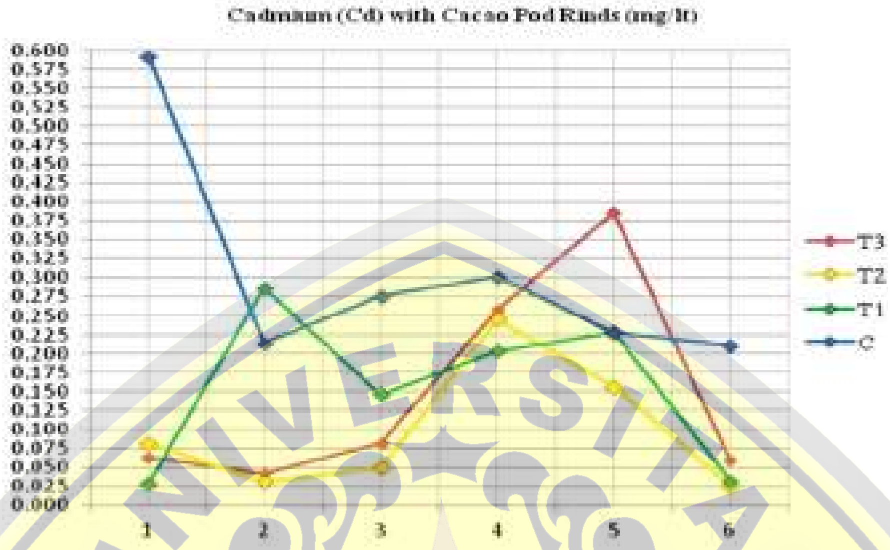

Fig. 18.5 Cd in the C, T1, T2 and T3 groups in the 48-h period

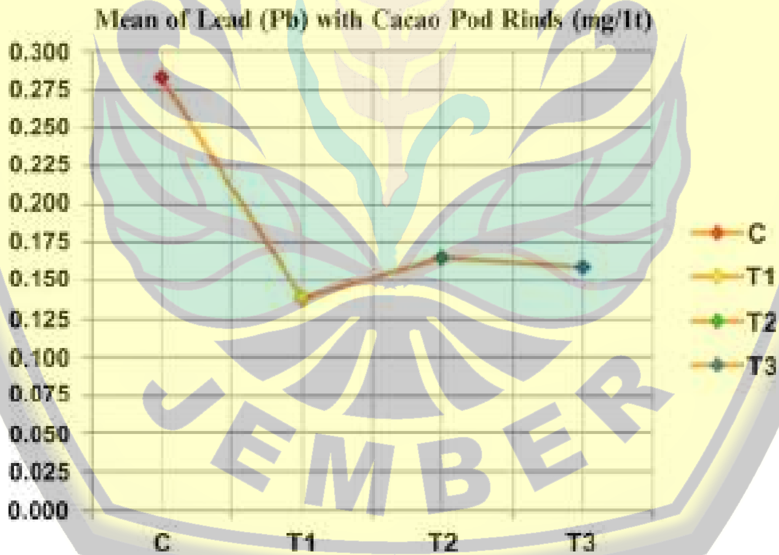

Fig. 18.6 Mean Pb in the C, T1, T2 and T3 groups in the 48-h period

ion concentration, temperature, pH, adsorbent dosage and contact time can affect the heavy metal binding properties.

Treatment group 1 (100 g cacao pod rinds/L) exhibited the greatest binding of Pb in 48 h compared to treatment groups 2 and 3. Treatment groups 2 and 3 could not

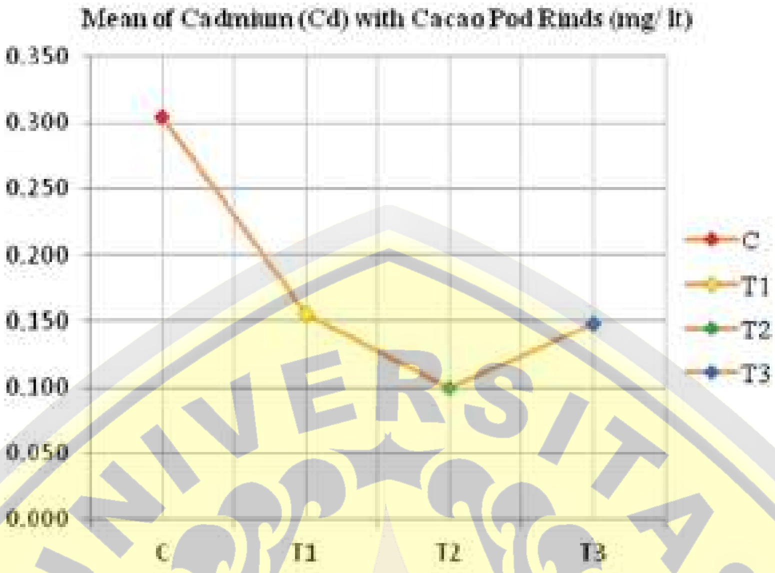

Fig. 18.7 Mean Cd in the C, T1, T2 and T3 groups in the 48-h period

bind optimally with Pb; it probably occurred because the peptin of cacao pod rinds saturated and could not adequately adsorb the Pb, which remains in the water. Treatment group 2 (300g cacao pod rind/L) showed the highest binding of Cd in 48 h. Treatment group 1 (100 g cacao pod rinds/L) showed that cacao pod rinds were insufficient to bind with Cd, whereas treatment group 3 showed that the cacao pod rinds were probably saturated and could not adequately adsorb the Cd, which remained in the water.

18.3.2.1 Test Analysis of Differences

The Kolmogorov-Smirnov normality test showed that the data from all groups for both parameters Pb and Cd have normal distributions (Sig $p = 0.2$ with $\alpha > 0.05$ and Sig $p = 0.826$ with $\alpha > 0.05$, respectively). The test of homogeneity of variance showed that Pb does not have the same variance (Sig 0.19). The Welch's F test indicates that there are significant differences in the levels of Pb in the control group (C) and the treatment groups ($F = 7.125$; Sig 0.002). There are also differences between the control and the individual treatment groups T1, T2 and T3 (Sig 0.00; 0.003; 0.002) (Table 18.1). The test of homogeneity of variance showed that Cd does have the same variance (Sig 0.677). One-way ANOVA test showed the value of $F = 3.142$ and Sig 0.048, so there was a significant difference between the control and treatment groups T1, T2, T3. Furthermore, the LSD post hoc test was conducted to determine whether there are differences between the groups. The LSD post hoc test results showed there were significant differences between the control

Table 18.1 The standard deviation of each group for Pb among C, T1, T2 and T3 groups

	N	Standard deviation
Control	6	0.0992566
T1	6	0.0572762
T2	6	0.0259262
T3	6	0.0246772

Table 18.2 The standard deviation of each group for Cd among C, T1, T2 and T3 groups

	N	Standard deviation
Control	6	0.1457816
T1	6	0.1061937
T2	6	0.0866020
T3	6	0.1410541

group (C) and individual treatment groups T1, T2 and T3 (Sig 0.048; 0.009; 0.04) (Table 18.2).

The local cacao pod rind waste from Jember, Indonesia, has the potential to adsorb and bind heavy metals Pb and Cd because of its constituent pectin. Cacao pod rind was an organic material. The pectin in cacao pod rind waste from other countries may be different, because of age, type, soil conditions, harvest time, climate, etc. Some organic materials can be used economically as adsorbents. Balaria (2006) showed that citrus pectin from citrus peels can bind Pb. Similarly, walnut peels can adsorb Zn (Liu et al. 2014; Sudha et al. 2015), and *Citrus limettioides* (lime) peel and seed can adsorb Ni(II) (Liu et al. 2014; Hussen 2014), while orange peel is effective in the recovery of Ni (Santos et al. 2015). Potato peels can adsorb Cr(IV) (Mutongo et al. 2014), mangosteen peels are effective in Cr(IV) removal (Huang et al. 2013), pineapple peel can adsorb Cu^{2+} and Pb^{2+} (Hu et al. 2011) and jackfruit peel can adsorb Cd(II) (Inbaraj and Sulochana 2004).

Further research are needed to measure the pectin from cacao pod rind from Jember, Indonesia, and other countries to identify their characteristics to adsorb the Pb and Cd. The ability of pectin from cocoa pod rind to bind Pb and Cd depends on many confounding factors such as age of the cacao tree, type, soil conditions, harvest time, climate, etc. Therefore, the further reseach needs to control all the confounding factors and using artificial polluted water which contain the amount of Pb and Cd.

18.4 Conclusion

Cacao pod rind waste from cacao trees in Jember, Indonesia, has the potential to adsorb heavy metals such Pb and Cd in water. Cacao pod rind waste is adsorbent, odourless and brownish in colour and has a good appearance and texture after 48 h in water. Using the cacao pod rind waste to bind the Pb and Cd in the polluted water has more advantages than chemical treatment or ion exchange. Besides that, it can help mitigate the cacao pod rind waste from cacao plantations and improve the economics of cacao production.

This is a simple application of binding Pb and Cd in the polluted water using the cacao pod rind. It just needs a thin husk peeled-off the cacao pod rind and then chopped it into 1x2 cm^2 in size before contacting them with the polluted water for 48 h. It is easy to use and can help environmental sustainability.

Acknowledgments This work was supported by Jember University, Indonesia [Grant number DIPA *Jember University 2013, DIPA -023.04.2.414.995/2013 Mei 2013].*

References

Apostoli, P, Cornelis R, Duffus J, Hoet P, Lison D, Templeton D (2006) Elemental speciation in human health risk assessment. World Health Organization [online at] http://www.inchem.org/documents/ehc/ehc/ehc003.htm. Accessed 20 Jan 2013

Asraf MA (2010) Universitas Sumatera Utara, 2011. Kandungan Pektin Memiliki Daya Serap terhadap Logam Tembaga dan Seng [online at] http://repository.usu.ac.id/bitstream/123456789/22340/4/Chapter%20I.pdf. Accessed 12 Jan 2014

Balaria A (2006) Biosorption of lead by citrus pectin and peels in aqueous solution. Univ. Alaska Fairbanks thesis (M.S.), [online at] http://www.scolarworks.alaska.edu/handle/11122/4945?show=full. Accessed 2 Jan 2014

Cocoa Bean (2015) Wikipedia [online at] https://en.wikipedia.org/wiki/Cocoa_bean. Accessed 14 Jan 2014

Conrad K (2008) Correlation between the distribution of lignin and pectin and distribution of sorbed metal ions (lead and zinc) on coir (Cocos nucifera L). Bioresour Technol 99 (17):8476–8484

Dronnet VM, Renard CMGC, Axelos MAV, Thibault J-F (1996) Heavy metal binding by pectins: selectivity, quantification and characterisation. Pectin and Pectinases. Abstract, Prog. on Biotechnol, Proc Int Symp 14:535–540. [online at] http://www.sciencedirect.com/science/article/pii/S0921042396802838. Accessed 14 Jan 2014

Ministry of Health of Indonesia, Regulation Number 416 of 1990 about Terms and supervision of water quality

Ministry of Health of Indonesia, Regulation Number 907 of 2002 about Terms and supervision of drinking water quality

Ministry of Health of Indonesia, Regulation Number 492 of 2010 about Water quality requirements

Hu X, Zhao M, Song G, Huang H (2011) Modification of pineapple peel fibre with succinic anhydride for Cu^{2+}, Cd^{2+} and Pb^{2+} removal from aqueous solutions. Environ Technol 32 (7–8):739–746. Abstract [online at] http://www.ncbi.nlm.nih.gov/pubmed/21879549. Accessed 2 Jan 2014

Huang K, Xiu Y, Zhu H (2013) Selective removal of Cr(VI) from aqueous solution by adsorption on mangosteen peel. Environ Sci Pollut Res 20(9):5930–5938. Abstract [online at] http://www.ncbi.nlm.nih.gov/pubmed/23397175. Accessed 2 Jan 2014

Hussen RA (2014) Assessment of the effectiveness of orange (Citrus Reticulata) peel in the recovery of nickel from electroplating wastewater. J Egypt Public Health Assoc 89 (3):154–158. Abstract [online at] http://www.ncbi.nlm.nih.gov/pubmed/25534181. Accessed 2 Jan 2014

Inbaraj BS, Sulochana N (2004) Carbonised jackfruit peel as an adsorbent for the removal of Cd (II) from aqueous solution. Bioresour Technol 94(1):49–52. Abstract [online at] http://www.sciencedirect.com/science/article/pii/S0960852403003407. Accessed 2 Jan 2014

Jember, Indonesia official website 2012 [online at] http://ciptakarya.pu.go.id/profil/profil/barat/jatim/jember.pdf. Accessed 10 Feb 2014

Liu XH, Wang XW, Zhao B, Lü JF, Kang NN, Zhang YJ (2014) Preparation and optimum process of walnut peel activated carbon by zinc chloride as activating agent. Guang Pu Xue Yu Guang Pu Fen Xi, 34(12) 3350–3353. [online at] http://www.ncbi.nlm.nih.gov/pubmed/25881437. Accessed 2 Jan 2014

Minister of Health of Indonesia, Regulation Number 416 /1990 about water quality standard and water monitoring

Minister of Health of Indonesia, Regulation Number 907/2002 about water quality standard and drinking water monitoring

Moelyaningrum AD, Pujiati RS (2015) Cadmium (Cd) and mercury (Hg) in the soil, leachate and ground water at the final waste disposal Pakusari Jember Distric Area. Int J Sci Basic Appl Res 24(2):101–108

Mutongo F, Kuipa O, Kuipa PK (2014) Removal of Cr(VI) from aqueous solutions using powder of potato peelings as a low cost sorbent. Bioinorg Chem Appl 2014:973153. doi:10.1155/2014/973153. Abstract http://www.ncbi.nlm.nih.gov/pubmed/25136289. Accessed 2 Jan 2014

Santos CM, Dweck J, Viotto RS, Rosa AH, de Morais LC (2015) Application of orange peel waste in the production of solid biofuels and biosorbents. Bioresour Technol 196:469–479. Abstract http://www.ncbi.nlm.nih.gov/pubmed/26280099. Accessed 2 Jan 2014

Sudha R, Srinivasan K, Premkumar P (2015) Removal of nickel(II) from aqueous solution using Citrus Limettioides peel and seed carbon. Ecotoxicol Environ Saf 117:115–123. Abstract [online at] http://www.ncbi.nlm.nih.gov/pubmed/25841067. Accessed 2 Jan 2016

Towle GA, Christensen O (1980) Pectin. In: Whistler R (ed) Industrial gums, 2nd edn. Academic Press, New York, pp 429–449

WHO (2011) Guidelines for drinking-water quality, 4th Ed. World Health Organisation (WHO) [online at] http://www.who.int/water_sanitation_health/publications/2011/dwq_chapters/en/. Accessed 1 Jan 2014

Widyasari N, Moelyaningrum AD, Pujiati R, Potensi A (2012) Pencemaran Timbal (Pb) pada tanah Air Lindi dan Air Tanah (Sumur Monitoring) di TPA Pakusari Kabupaten Jember [online at] http://www.repository.unej.ac.id. Accessed 21 Jan 2013