ISSN NO: 2771-8840
Date of Publication: 21-08-2022

The Use of the (Cynodon Dactylon) Plant Waste for the Removal of Nickel and Cadmium from Aqueous Solutions by Adsorption

Ali K. Al-Muttairi
Environmental Studies and Research Center\ University of Babylon
Corresponding Author: allmankind10@gmail.com

Abstract: This study was carried out to find a new, affordable, and ubiquitous adsorbent that has the ability to remove trace metals. In this study, *Cynodon dactylon* dried grass was used. The proposed adsorbent shows a faster and higher removal for Cadmium (Cd) than it was for Nickel (Ni). The removal efficiency (R%) was decreased from 78 to52% and from 32 to 13 % for Cd and Ni respectively as the initial metal concentrations increased from 10 to 50 ppm. while the R% increased from 52 to 63% and from 13 to 17% for Cd and Ni respectively as the adsorbent weight increased from 0.25 to 0.5 gm and after that it reach equilibrium. On the other hand, Cd removal was the highest in acidic conditions while Ni removal was highest in alkaline conditions. Throughout the whole study, the proposed adsorbent shows a much higher ability to remove Cd than it was for Ni.

Introduction

Water is the source of life, and without it, no life form can exist. Three-quarters of the living human body consists of water, and almost 90% of the plant is water. this essential element is under ever-growing stress due to elevated consumption and raising pollution levels caused by various anthropogenic activities, and that goes for both developed and developing countries [1]. Among these pollutants that can pollute water bodes heavy metals rise attention due to their effect on public health. Heavy metals can enter water bodies via natural and man-made sources. The natural sources include weathering and erosion, while the man-made sources include industrial, agricultural, and household wastes respectively [2]. Heavy metals are metals and metalloids that have a density of more than 4 g $cm^{-3.}$ They can cause cancers, heart and neuro-system diseases, and diabetes. Heavy metals that exist in water are soluble which are beaning uptake and accumulate in the food chain ultimately affecting human health [3]. Some heavy metals are necessary for the growth of humans, animals, and plants but up to certain permitted levels such as iron, copper, and zinc, but above that acceptable limit they become toxic. while, trace metals such as lead chromium, cadmium, arsenic, and mercury are toxic at any concentrations and have no role in the development of both animals and plants [4,5]

As mentioned above humans and other living organisms do not require cadmium and it has no essential role in their growth and development. But it’s required for a variety of industries such as batteries, plastic, alloys, and solar cells. The anthropogenic activities accounted for most of the cadmium that exists in the running water. exposure to cadmium can damage the immune system, growth, and reproduction as well as the endocrines [7].

On the other hand, Nickel is ubiquitous in the environment. It acts as an essential micro-nutrient in both hormones’ activities and in lipids metabolization [8]. correspondingly, nickel is extensively used in different industries including stainless-steel production, alloys, batteries, coins, electronics, and electroplating. Nickel can enter the water body through human activities such as metal-forging processes, fissile fuel burning chemical industries wastewater as well as sewage [9]. When come to contact nickel can cause allergy, heat and kidney illness, and damage to the lungs [10]. Nickel can be toxic, teratogenic, and carcinogenic as well [8].

Since those heavy metals can cause such drastic effects on the environment and health the different industries are obligated to minimize the concentrations of trace metals and other containments to the permissible limit before releasing them into the environment. That can be done using different chemical, physical and biological treatment methods, and among these treatment methods adsorption is considered more eligible since it can be cheap, efficient, and easy to apply. And there is an ongoing search for low-price, effective, available and eco-friendly adsorbent that is capable of removing heavy metals [6].

ISSN NO: 2771-8840
Date of Publication: 21-08-2022

The proposed adsorbent in this study is grass (*Cynodon dactylon*) which belongs to the family poeace, it's an ever-green grass, that is ubiquitous worldwide, especially in the hot regions. It has been used in traditional medicine due to its antimicrobial, antiviral, and antibacterial activities, it can be used as powder, extract and paste. It contains a variety of metabolites such as proteins, minerals, and carbohydrates as well as many secondary metabolites [11,12]

Many studies have been carried out to treat heavy metals by using different adsorbents. Khan *et al*., 2021[13] stated that charcoal produced from Wheat straw has strong efficiency in removing both cadmium and lead. Salman *et al.*, 2021 [14] found that activated carbon prepared from water hyacinth used as an adsorbent has a good ability in removing both lead and cadmium. Yirga *et al*., 2022,[15] investigated the ability of orange peel to adsorb both copper and cadmium. The adsorbent was able to remove both copper and cadmium with a removal percentage of 96.9 and 98.1% respectively. The ajwa date pits were used as adsorbent by Azam *et al.* 2022 [16] for the adsorption of copper from the aqueous solutions. The study state that the ajwa date pits have the potential to act as an adsorbent for copper.

Materials and methods
Experimental work in this study was carried out according to [17, 18].

Adsorbent
In this study *Cynodon dactylon* was cut down dried in air and then grained by using an electrical mortar to fine powder without activation as shown in Fig.1 A and B.

A B
Fig.1: A) the dry grass B) grinded grass

Adsorbate
A slandered solutions of Both cadmium and Nickel (with 1000 ppm) was prepared, and then the required concentrations were set from these slandered solutions

Batch studies
Four experiments were carried out to investigate the ability of the suggested adsorbent to adsorbs both Cd and Ni respectively. The first experiment was to estimate the best contact time for adsorption by using a sample size 50 ml, initial metal (Cd and Ni) concentration was 50 ppm, the adsorbent dose was 0.75gm and the samples were collected on a series of interval times (30, 60, 90 120, and 150 minutes respectively).

The second experiment was used to show the effect of the initial Cd and Ni concentrations on the adsorption process. The sample size was 50 ml, the contact time for Cd was 90 minutes and for Ni was 150 minutes, the adsorbate dose was 0.75 gram, and a series of initial Cd and Ni concentrations (10, 20, 30, 40, and 50 ppm respectively).

The third experiment was done to illustrate the effect of adsorbate dose on the adsorption process. The sample size was 50ml, contact time for Cd was 90 minutes and for Ni was 150 minutes, initial dye concentration was 50 ppm and a series of the adsorbent dose was used (0.25, 0.5, 0.75, 1, and 1.5gm respectively).

ISSN NO: 2771-8840
Date of Publication: 21-08-2022

The last experiment was carried out to investigate the effect of the aqueous solution pH value. The sample size was 50ml, contact time for Cd was 90 minute and for Ni was 150 minutes, initial dye concentration was 50 ppm, the adsorbent dose was 0.75 gm and four pH value was used 3, 5,7, and 9 respectively.

The samples resulting from the four experiments were centrifuged at 5000 rpm for 5 minutes, the supernatant was taken and recentrifuged at 5000 rpm for 3 minutes and then the supernatant was taken the concentration of Cd and Ni was measured by using atomic absorption spectrophotometer.

Results and Discussion

The first experiment show that the proposed adsorbent has a moderate ability for removing cadmium at an initial concentration of 50ppm and it was showing that reach the highest removal efficiency(R%) after 90 minutes and after that, there was a consistency in removal efficiency of Cd as showing in Fig.1. and finding the best contact time is a crucial from both times consume as well as economical aspects in the treatment applications [19] And the reason for that could be due to the fact that at early stages of adsorption there plenty of vacant active site and after reaching equilibrium the adsorption site is filled with Cd ions which produce repulsive force for the remaining Cd ions [20]. the findings of this study aligned with the results of [21] which found the AMMH adsorbent shows a fast removal of Cd after 90 minutes and afterward, the adsorption slows down [22]

While the results show that it has a weak ability in removing Ni and the removal efficiency was increased with increase of contact time up 150 minutes as shown in Fig. 1. which suggested a slow and weak ability of the proposed adsorbent in removing Ni. The study results aligned with the results of [23] which stated that the removal of nickel by chitosan-g-polyacrylonitrile was increased with the rise in contact time but with much lower removal efficiency achieved by our study.

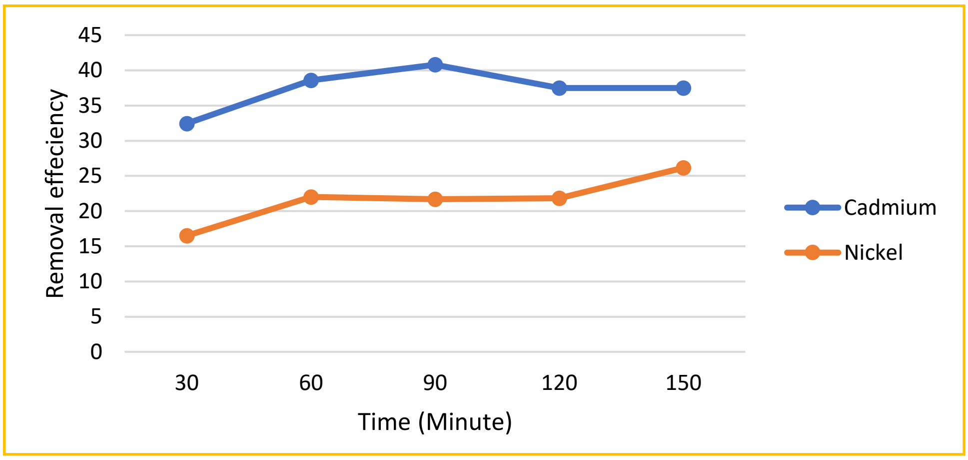

Fig.1: determine the best contact time for adsorption of both Cd and Ni.

There was a significant difference in the efficiency of the adsorbent in removing Cd when changing the Cd initial concentrations, the R% was reduced from 78.4 at Cd concentration 10 ppm to 52.46 at Cd concentration 50 ppm. Also, the results show a reverse correlation between the nickel concentration and R%. as illustrated in Fig.3 and Fig.4 respectively. This can be explained simply by the fact that as the initial concentrations of metals increase the available active sites will be reduced significantly which lead subsequently to decreasing the removal efficiency of the adsorbent [24]. the results are similar to the findings of [25] which found that as the initial concentration of Cu, Zn, and Ni increases the removal efficiency decrease. It also agrees with the findings of [26] that found the Cd removal by flaxseed reduced with the rase in the Cd concentrations.

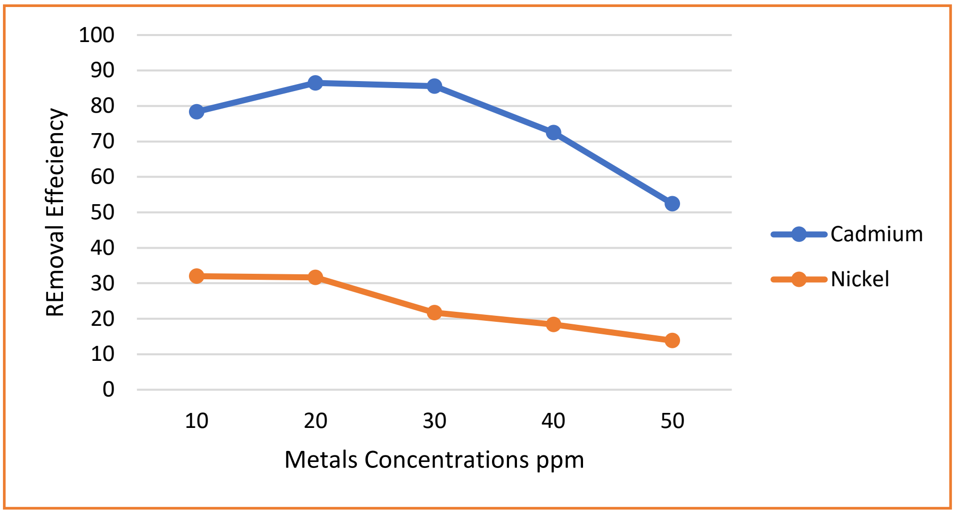

Fig.2: the effects of the initial Cd and Ni concentrations on the adsorption process

The adsorbent dose affects the R% of Cd, the increase of adsorbent dose up to 0.75 gm rase the R% and above that there was a constant in R% as illustrated in Fig. 3. And that because the increase in the adsorbent amount in the solution may cause aggregation that leads to the reduction of available active surface for adsorption, hence, the increase in the adsorbent weight does not cause an increase in the adsorption removal efficiency [27] that agrees with results of [28] when they use an adsorbent dose ranged from 0.1 to 4 gm the best adsorption rate of Cd was recorded at 1.5gm and above no increase was recorded in the adsorption of Cd.

While for the Ni removal there was no correlation between Ni removal and the increase in adsorbent dose, so that R% was dose-independent, and the adsorption was increased as the adsorbent weight increased from 0.25-0.5gm and then decrease with the increase in adsorbent weight. This is similar to the findings of [29] but with a much lower removal ability of Ni regarding the results of this study.

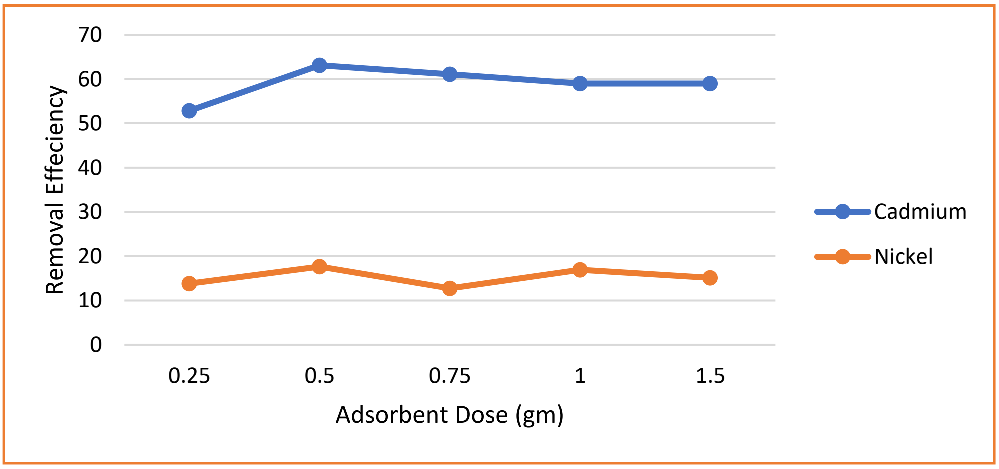

Fig.3: the effects of the adsorbent dose on the adsorption process of Cd and Ni

The pH value of the solution affects the R% of Cd, the lowest R% was at extreme acidity (pH=3) and at high alkalinity (pH=9), while the highest R% was recorded at Low acidity and neutral media respectively as illustrated in Fig.4. The lower removal efficiency at lower pH value can be due to the high H+ concentration which competes with Cd ions for the adsorption sites [30], as the pH value increases the adsorption of Cd increase while the high PH value (Alkaline) cause the heavy metal precipitation. This agrees with the findings of [21] which states that Cd adsorption on nano chitosan increases as the PH values increase from 2-5 up to 7.

On the other hand, the highest removal efficiency for Ni was observed in neutral media as shown in Fig. 4. And that the results can be explained by knowing that at a lower pH value of the solution the high protonation of the active sites on the adsorbent cause repulsion of the metals ions and decrease the adsorption

ISSN NO: 2771-8840
Date of Publication: 21-08-2022

with the increase of pH value up to neutral the repulsion decrease and thus increase the adsorption of Ni, while at high pH value the OH compete with the Ni ions for the adsorption sites [31].

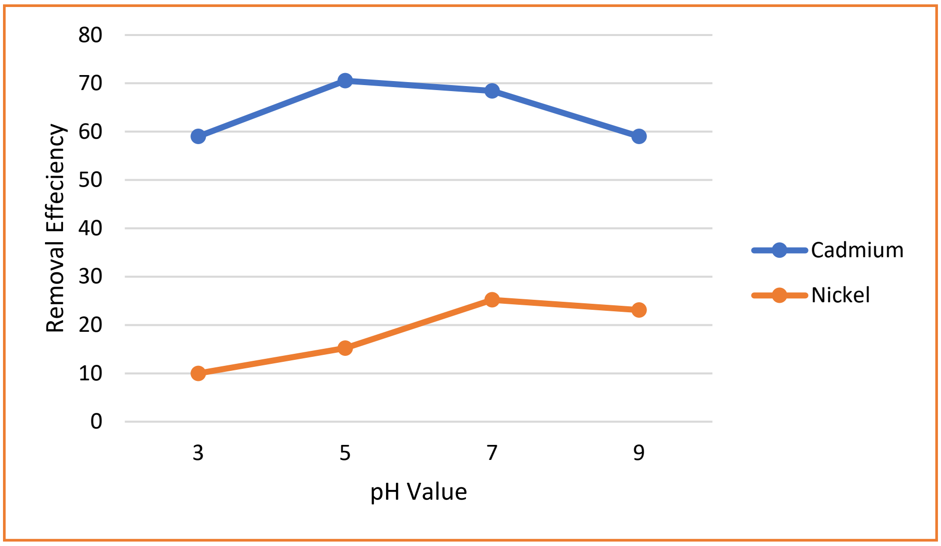

Fig.4: the effect of the pH value on the adsorption process

References

[1] Al-Taai, S. H. H. Water pollution Its causes and effects. First International Virtual Conference on Environment & Natural Resources. IOP Conf. Series: Earth and Environmental Science 790 (2021) 012026 IOP Publishing.2021. doi:10.1088/1755-1315/790/1/012026.

[2]: Acharjee, A.; Ahmed, Z.; Kumar, P.; Alam, R.; Rahman, M.S. and Simal-Gandara, J. Assessment of the Ecological Risk from Heavy Metals in the Surface Sediment of River Surma, Bangladesh: Coupled Approach of Monte Carlo Simulation and Multi-Component Statistical Analysis. Water. 2022. Vol.14, No.180. https://doi.org/10.3390/w14020180

[3] Pan, H.; Zhou, G.; Yang, R.; Cheng, Z. and Sun, B. Heavy Metals and as in Ground Water, Surface Water, and Sediments of Dexing Giant Cu-Polymetallic Ore Cluster, East China. Water. 2022. Vol.14, No.352. https:// doi.org/10.3390/w14030352

[4] Akhtar, N.; Syakir Ishak, M.I.; Bhawani, S.A. and Umar, K. Various Natural and Anthropogenic Factors Responsible for Water Quality Degradation: A Review. Water. 2021. Vol.13, 2660. https://doi.org/10.3390/ w13192660

[5]Gaur, V. K.; Sharma, P.; Gaur, P.; Varjani, S.; Ngo, H. H.; Guo, W.; Chaturvedi, P.; and Singhania, R. R. Sustainable mitigation of heavy metals from effluents: Toxicity and fate with recent technological advancements. *Bioengineered*.2021. Vol.*12*,No.1: 7297–7313. https://doi.org/10.1080/21655979.2021.1978616

[6] Yusuff, A. S. *Adsorptive removal of lead and cadmium ions from aqueous solutions by aluminium oxide modified onion skin wastes: Adsorbent characterization, equilibrium modelling and kinetic studies . Energy & Environment,* 2021 *(),* –. doi:10.1177/0958305x21989886

[7]EPA. Aquatic Life Ambient Water Quality Criteria Update for Cadmium – 2016. Office of Water EPA 822-F-16-003 March 2016.

[8] Zdrojewicz, Z., Popowicz, E., & Winiarski, J. Nikiel - rola w organizmie człowieka i działanie toksyczne [Nickel - role in human organism and toxic effects]. Polski merkuriusz lekarski : organ Polskiego Towarzystwa Lekarskiego. 2016. Vol.41, No.242:115–118.

[9] World Health Organization. Nickel in drinking water: background document for development of WHO Guidelines for drinking-water quality. World Health Organization. 2021. https://apps.who.int/iris/handle/10665/350934

[10] Genchi,G.; Carocci, A.; Lauria,G.; Sinicropi, M. S. and Alessia Catalano, A. Nickel: Human Health and Environmental Toxicology. Int J Environ Res Public Health. 2020. Vol.17, No.3: 679. Published online 2020 Jan 21. doi: 10.3390/ijerph17030679

ISSN NO: 2771-8840
Date of Publication: 21-08-2022

[11] Ashokkumar, K.; Selvaraj, K. and Muthukrishnan,S. D. Cynodon dactylon (L.) Pers.: An updated review of its phytochemistry and pharmacology . Journal of Medicinal Plants Research.2013. Vol. 7, No.48: 3477-3483.
[12] Shendye, N. V. and Gurav, S. S. Cynodon dactylon: a systemic review of pharmacognosy, phytochemistry and pharmacology. International Journal of Pharmacy and Pharmaceutical Sciences. 2014.Vol 6, No.8: 7-12
[13]Khan, M.N.; Ullah, H.; Naeem, S.; Uddin, J.; Hamid, Y.; Ahmad, W.; Ding, J. Remediation of Emerging Heavy Metals from Water Using Natural Adsorbent: Adsorption Performance and Mechanistic Insights. Sustainability. 2021. Vol.13, 8817. https://doi.org/ 10.3390/su13168817
[14] Salman, S. D.; Rasheed, I. M. and Mohammed, A. K. Adsorption of heavy metal ions using activated carbon derived from Eichhornia (water hyacinth). 5ISCESD 2021 IOP Conf. Series: Earth and Environmental Science 779.2021. 012074 IOP Publishing doi:10.1088/1755-1315/779/1/012074
[15] Yirga, A.; Yadav, O. P. and Dey, T.. Waste Orange Peel Adsorbent for Heavy Metal Removal from Water. Pollution. 2022. Vol.8, No.2: 553-566 DOI: 10.22059/POLL.2021.331156.1193.
[16]Azam, M.; Wabaidur, S.M.; Khan, M.R.; Al-Resayes, S.I.; Islam, M.S. Heavy Metal Ions Removal from Aqueous Solutions by Treated Ajwa Date Pits: Kinetic, Isotherm, and Thermodynamic Approach. Polymers. 2022. Vol.14, 914. https://doi.org/ 10.3390/polym14050914
[17]Al-Defiery, M. E.; Al Muttairi, A. K.; Omran, A.;Yasin, A. M. and Kazam, M. S. A comparative study to estimate the ability of three waste organic materials to remove methylene blue and Congo red Dyes from aqueous solutions. 1st international virtual conference of environmental sciences. IOP Conf. Series: Earth and Environmental Science 722. 2021. 012018. IOP Publishing. 2021. doi:10.1088/1755-1315/722/1/012018
[18] Al-Muttairi, A. K.; Musatfa, S. A. and Salman, J. M. A Comparative Efficiency Study of Two Adsorbent Materials to Remove EosinY Dye from Aqueous Solutions. Baghdad Science Journal. 2018. Vol.15, No. 4: 387-391.
[19] Noureddine, F. K. and Ncibi, A. M. C. Adsorptive removal of cadmium from aqueous solution by cork biomass: Equilibrium, dynamic and thermodynamic studies. Arabian Journal of Chemistry. 2016. Vol.9:s1077-s1083.
[20]Saini, S., Katnoria, J. K., and Kaur, I. A comparative study for removal of cadmium (II) ions using unmodified and NTA-modified Dendrocalamus strictus charcoal powder. Journal of Environmental Health Science and Engineering.2019. doi:10.1007/s40201-019-00345-2
[21]Alyasi, H.; Mackey, H. R. and McKay, G. *Removal of cadmium from waters by adsorption using nanochitosan. Energy & Environment,2019. (), 0958305X1987619–.* doi:10.1177/0958305X19876191
[22] Giwa, A. A.; Bello, I. A.; Oladipo, M. A. and D. O. Adeoye, D. O. Removal of Cadmium from Waste-water by Adsorption Using the Husk of Melon (Citrullus lanatus) Seed. International Journal of Basic and Applied Science.2013. Vol. 02, No. 01: 110-123.
[23] Shanmugapriya, A.; Hemalatha, M.; Scholastica, B. and Augustine, A. P.T. Adsorption studies of lead (II) and nickel (II) ions on chitosan-G-polyacrylonitrile. Der Pharma Chemica. 2013. Vol. 5, No.3:141-155.
[24]El-Sadaawy, M. and Abdelwahab, O. Adsorptive removal of nickel from aqueous solutions by activated carbons from doum seed (Hyphaenethebaica) coat. Alexandria Engineering Journal.2014. Vol.53, No.2: 399–408. doi:10.1016/j.aej.2014.03.014
[25]Punrattanasin, P. and Sariem, P. Adsorption of Copper, Zinc, and Nickel Using Loess as Adsorbents. Pol. J. Environ. Stud.2015. Vol. 24, No. 3:1259-1266.
[26] Jasim, N. A. and Hussein, T. K. Removal of Cadmium Ions from Aqueous Solutions Using Flax Seeds as an Adsorbent. Diyala Journal of Engineering Sciences. 2019. Vol. 12, No. 04:01-08.
[27] Delil, A. D.; Gülçiçek, O. and Gören, N. Optimization of Adsorption for the Removal of Cadmium from Aqueous Solution Using Turkish Coffee Grounds. International Journal of Environmental Research,2019. (), –. doi:10.1007/s41742-019-00224-6
[28] Bassam, R.; El hallaoui, A.; El Alouani, M.; Jabrane, M.; El Khattabi,E.; Tridane, M.; and Belaaouad, S. Studies on the Removal of Cadmium Toxic Metal Ions by Natural Clays from Aqueous Solution by Adsorption Process. Hindawi Journal of Chemistry.2021. Vol. 2021, Article ID 7873488, 14 pages https://doi.org/10.1155/2021/7873488.

ISSN NO: 2771-8840
Date of Publication: 21-08-2022

[29]Agila, A.; Rosaline, V. J. and Stella, B. M. Adsorption of nickel (II) by low cost Hopea parviflora Saw dust. journal of Pharmacognosy and Phytochemistry. 2018. Vol.7, No.3: 2452-2455.

[30] Pérez-Marín, A. B.; Meseguer Zapata, V.; Ortuño, J. F.; Aguilar, M.; Sáez, J.; Lloréns, M. Removal of cadmium from aqueous solutions by adsorption onto orange waste.2007. Vol.139, No.1: 122–131. doi:10.1016/j.jhazmat.2006.06.008 .

[31] Hannachi, Y.; Shapovalov, N. A. and Hannachi, A. Adsorption of Nickel from aqueous solution by the use of low-cost adsorbents. Korean J. Chem. Eng.,2010. Vol. 27, No.1:152-158.DOI: 10.1007/s11814-009-0303-7.