ISSN: 0974-5823 Vol. 7 No. 1 January, 2022

International Journal of Mechanical Engineering

Removal of Heavy Metals from Water by Adsorption Method using Clam Shells

S.Baskar[a*]; Dr.K.R.Aswin Sidhaarth[b] and Dr.L.Mangaleshwaran[c]

[a] *PhD Scholar, Assistant Professor, Department of Civil Engineering, Vel Tech Rangarajan Dr.Sagunthala R&D Institute of Science and Technology, Avadi, Chennai, Tamil Nadu, India*

[b] *Associate Professor, Department of Civil Engineering, Vel Tech Rangarajan Dr.Sagunthala R&D Institute of Science and Technology, Avadi, Chennai, Tamil Nadu, India*

[c] *Assistant Professor, Department of Civil Engineering, Alagappa Chettiar Government College of Engineering and Technology, Karaikudi,Tamil Nadu, India*

Abstract

Study aims to investigate effectiveness of clam shells as an adsorbent to remove mercury from water. Adsorption is a potential approach for removing heavy metals that have harmful effects on both aquatic system and humans. The goal of this work is to determine the efficiency of these shells in removing mercury from synthetic wastewater. Scanning electron microscope and transmission electron microscope used to determine surface morphologies and sizes. Size ranged from 20 to 60 nanometers. The mechanism of interaction between the shells and Hg2+ was studied using a UV-Visible spectrometer. Results of experiments revealed that shell's removal efficiency was 90% when mixed with a pH 6 or less.

Keywords: Adsorption, Mercury, Clam shell, UV-Visible Spectrophotometer.

1. Introduction

Mercury cycle is a process that occurs naturally in Earth's crust and its various forms on planet's surface. Health hazard refers to chemicals that are toxic or highly toxic and can cause adverse effects. Pirrone and colleagues (Pirrone et al., 1996) From 1990 to 1995, this figure was somewhat lower than predicted value of 2217. In late twentieth century, amount of mercury released into atmosphere from natural and re-emitted sources was estimated to be between 1500 and 2500 metric tonnes per year (Nriagu, 1989; Nriagu,1990). Barbosa and Soares de Almeida (2001); Barbosa and Soare Mercury remains in environment for a long time. As a result, efficient remedial approaches for lowering mercury levels in substantially mercury-polluted aquatic systems are required. Active remedial methods for polluted silt in aquatic systems include capping and dredging. Dredging is a technique for restoring normal water circulation and removing benthic silt.

Hosokawa Dredging appears to be an efficient treatment for mercury-polluted systems. Mercury levels in deposited sediment in Minamata Bay, Japan, were as high as 600 mg/kg (Hosokawa, 1993). Dredging project started in 1977 and finished in 1990. Data from monitoring reveals that meticulous dredging did not have a substantial negative influence on ecosystem due to sediment resuspension.

2. Aim and Background

- To investigate "Removal of Mercury from Synthetic Waste Water Using Clam Shell Nanoparticles Adsorption Method."
- Using SEM and TEM characterisation tests, assess surface shape and size of nanoparticles.
- Using batch tests, determine efficacy of produced nanoparticles as an adsorbent and investigate process control factors such as contact duration, adsorbent dose, solution pH, adsorbate concentration, and agitation speed.

Ennore Creek has a long history of influencing lives of those who live around it. Magnitude of environmental and health risk connected with it determined by early field research and contact with local populace. Severity of Ennore Creek's ecological deterioration may have an impact on health and living situations of area's stakeholders. Several occurrences and research have revealed pollution has resulted in fish deaths and health risks among Ennore's fishermen. During early research, many respondents believed severely polluted Ennore Creek taints quality of fishing items. Some people were concerned about ability of fish to migrate over belt. There have been encroachments for new structures that might supplant traditional fishermen as shown in Figure 1.

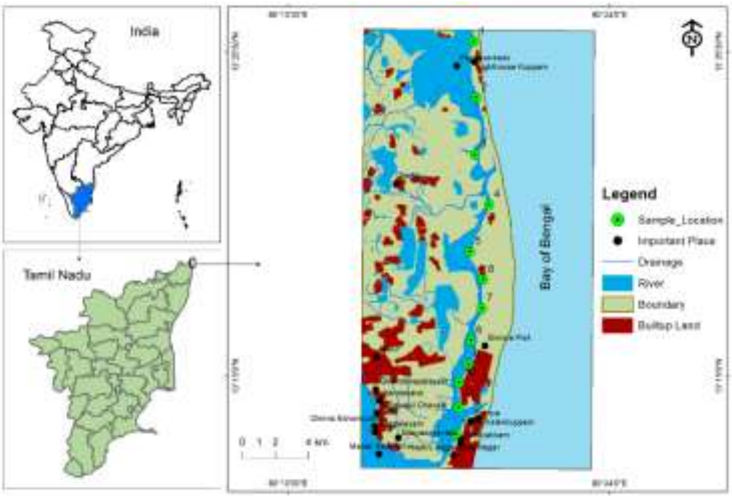

Figure 1 Location of study Area

3. Methodology

Adsorption of molecules or particles on a surface is referred as adsorption. Although all solid stuff has a surface, some are more effective than others. Adsorbing molecules are mostly organic and might be natural or manufactured. Viruses, bacteria, cysts and algae are examples of particles. Adsorption is process of collecting in solution chemicals on a suitable surface. Adsorption is a mass transfer process in which a liquid phase ingredient is transferred to solid phase. At interface, adsorbate is material extracted from liquid phase. Adsorbent is solid, liquid or gaseous phase that adsorbate adheres to.

3.1 Procedure - removal of mercury from water by adsorption method

To make a stock solution of Mercuric Chloride solution with concentration of 1000 ppm by dissolving 5 grams of Mercury Chloride in distilled water, then adding sodium hydroxide pellets to increase basic nature of distilled water. Using dilution formula X1Y1=X2Y2, mercury chloride solutions of various concentrations (20 ppm, 40 ppm, 60 ppm, 80 ppm and 100 ppm) are created. Following preparation of several solutions, absorbance of each is determined using an ultra violet spectrophotometer with a wave length of 375nm.Results are jotted down on a piece of paper. Each conical flask is filled with 0.50gms of powdered clam seashell and coated with non-adsorbent cotton. Five conical flasks are placed in an orbital shaker, which spins at speed of 150 to 200 rpm for 10 to 30 minutes before conical flasks are removed. After filtering, absorbance value of each solution is examined. Following that, discovered Mercury may be eliminated by utilising powdered clam shells.

Technique aims to use adsorption method to synthesise carbonaceous nanoparticles. SEM and TEM characterisation techniques were used to assess surface shape and size of clam shell particles. Batch studies used to assess efficacy of produced nanoparticles as adsorbent, as well as to investigate process control factors such as contact duration, adsorbent dose, solution pH, adsorbate concentration and agitation speed. Table 1 lists specifics of sample acquired in field.

Table 1 Sample details collected in the field

S.No	Test Name	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	S11	S12
1	PH	7.5	7	7.5	7	7	7	7	6.5	7	7	7.5	7
2	Alkalinity	200	140	220	250	240	350	180	140	160	10	220	90
3	COD (mg/L)	520	1240	1120	1720	1640	1920	2080	2000	1320	1000	800	480
4	Fluoride (mg/L)	2	0.5	1	0	0.5	0	0	1	1	0.5	1	0.5
5	Iron (ppb)	0	0.3	2	3	2	1	2	2	0.3	0.3	2	2
6	Ammonia	1	2	1	5	5	5	1	1	1	2	1	0.5
7	Nitrite (mg/L)	1	1	0.5	0.5	1	1	1	1	1	1	0.5	0.5
8	Phosphate (mmol/L)	0	1	2	3	1	2	2	1	0.5	1	2	0.5
9	Residual chlorine (mg/L)	0	0.5	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.5	0.2	0

4. Results and Discussion

4.1 Effect of contact time

One of most significant elements in design of cost-effective waste water treatment system is equilibrium time as mentioned in Figure2. In a 50ml mercury solution at concentration of 50mg/L, 0.30g of Clam shell nanoparticles were added. Using ultra violet spectrophotometer, residual Mercury content in solution measured.

contact time was changed from 10 to 120 minutes in 10-minute intervals. At contact period of 10 minutes, highest removal effectiveness was reported to be 90%. At this optimum contact time, more batch investigations were conducted. trial lasted between 0 and 120 minutes. There was steady progressive drop after 10 minutes. From this experiment, optimum contact duration was determined to be 10 minutes which shown in Table 2. and this number was taken into consideration going forward.

Table 2. Optimum contact duration

S.No	Time (Mins)	PH values	Initial concentration (mg/l)	Adsorbent Value(g)	RPM	Final concentration	Efficiency
1	10	8	50	0.3	100	7	86
2	20	8	50	0.3	100	9	82
3	30	8	50	0.3	100	11	78
4	40	8	50	0.3	100	13	74
5	50	8	50	0.3	100	15	70
6	60	8	50	0.3	100	16	68
7	70	8	50	0.3	100	18	64
8	80	8	50	0.3	100	19	62
9	90	8	50	0.3	100	16	68
10	100	8	50	0.3	100	14	72
11	110	8	50	0.3	100	13	74
12	120	8	50	0.3	100	12	76

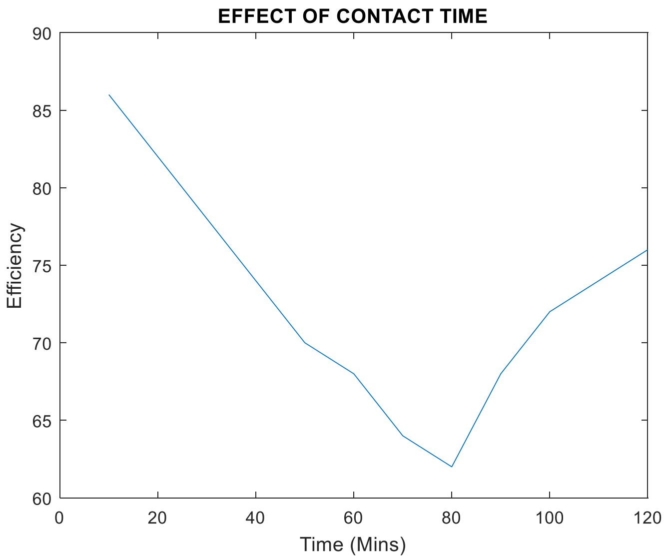

Figure 2: Effect of contact time Vs Time

4.2 Effect of adsorbent dosage

Size and quantity of adsorbent, which must be tuned, is one of most crucial criteria for quick and effective metal removal. Capacity of an adsorbent for a given starting concentration of Mercury solution is determined by adsorbent dosage, which is essential parameter in adsorption research as shown in Table 3.

Mercury solution was 50ml in volume. removal effectiveness seen to progressively drop in beginning owing to availability of active sites, and then to slightly rise over range of 0.05-0.50g. Best dosage was discovered to be 0.45g. contact time was set to ten minutes as referred in Figure 3.

Table 3. Effect of adsorbent Dosage 0.45(g)

S.No	Time	PH values	Initial concentration Mg/l	Absorbent (g)	RPM	Final concentration	Efficiency
1	10	8	50	0.05	100	26	48
2	10	8	50	0.10	100	22	56
3	10	8	50	0.15	100	20	60
4	10	8	50	0.2	100	17	66
5	10	8	50	0.25	100	15	70
6	10	8	50	0.3	100	13	74
7	10	8	50	0.35	100	11	78
8	10	8	50	0.4	100	10	80
9	10	8	50	0.45	100	8	84
10	10	8	50	0.5	100	7	86

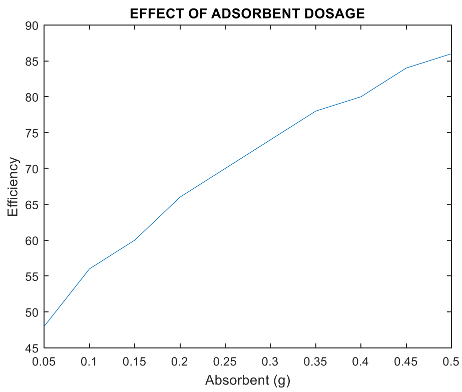

Figure 3. Effect of Absorbance dosage

4.3 Effect of Ph value

pH range in plating industry effluent is frequently rather large. As a result, pH of system is crucial in plating waste treatment. aqueous chemistry and surface bonding sites of adsorbents are both affected by pH as shown in Table 4. concentration of effluents discharged by companies will vary, similar to pH.

Experiment was conducted out with a dose of 0.45g and an optimal contact duration of 10 minutes. sample was agitated at a speed of 100rpm. This effect is explained by fact that when pH rises, more negatively charged surfaces become accessible, allowing for higher metal absorption. optimal dosage was discovered to be 8 and beginning concentration to be 50mg/l based on experimental findings which is mentioned in Figure 4.

Table 4. Effect of PH

Sl.No	Time	PH values	Initial concentration	Adsorbent (g)	RPM	Final concentration	Efficiency
1	10	1	50	0.45	100	24	52
2	10	2	50	0.45	100	22	56
3	10	3	50	0.45	100	21	58
4	10	4	50	0.45	100	18	64
5	10	5	50	0.45	100	12	76
6	10	6	50	0.45	100	14	72
7	10	7	50	0.45	100	15	70
8	10	8	50	0.45	100	17	66
9	10	9	50	0.45	100	19	62
10	10	10	50	0.45	100	21	64
11	10	11	50	0.45	100	22	58
12	10	12	50	0.45	100	26	48
13	10	13	50	0.45	100	29	42
14	10	14	50	0.45	100	32	36

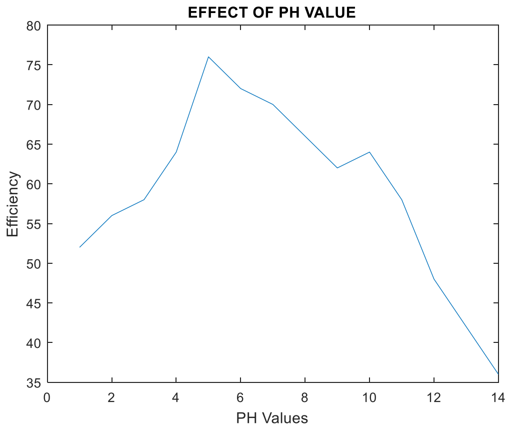

Figure 4. Effect of PH value

4.4 Effect of concentration of mercury

- Effect of starting concentration was investigated at concentrations ranging from 10 to 100 mg/L. With a dose of 0.45g and a pH of 8, experiment was carried out for an optimal contact time of 10 minutes as mentioned in Table 5.
- Optimal values for duration of relationship, adsorbent dose, and pH of aqueous solution were obtained from earlier tests, and remaining agitation speed candidate value was kept constant. optimal concentration was discovered to be 50mg/l based on experimental findings mentioned in Figure 5.

Table 5. Effect of concentration of mercury

Sl.No	Time (mins)	PH value	Quantity of solution (ml)	Initial concentration (mg/l)	Concentration of Adsorbent (g)	RPM	Final concentration	Efficiency
1	10	8	50	10	0.45	100	30	50
2	10	8	50	20	0.45	100	27	46
3	10	8	50	30	0.45	100	23	54
4	10	8	50	40	0.45	100	17	66
5	10	8	50	50	0.45	100	10	80
6	10	8	50	60	0.45	100	18	64
7	10	8	50	70	0.45	100	20	60
8	10	8	50	80	0.45	100	24	56
9	10	8	50	90	0.45	100	28	44
10	10	8	50	100	0.45	100	30	40

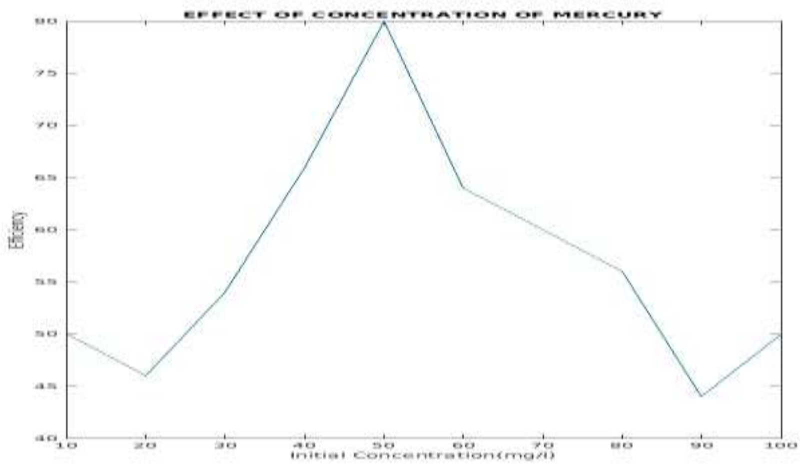

Figure 5. Effect of Concentration of mercury

4.5 Effect of speed of agitation

One of most critical design characteristics for an adsorption system is speed. For optimal removal, rate of interaction between adsorbent and adsorbate is an essential regulating parameter. Because it shows degree and rate of interaction between adsorbent and adsorbate, agitation speed is a significant design parameter in terms of removal efficiency as shown in Table 6.

Experiment was conducted at a speed of roughly 50-200rpm as shown in Figure 6. Other optimum parameter values include an adsorbent dose of 0.45g, a contact period of 10 minutes, a pH value of 8, and a starting lead concentration of 50mg/l. ideal speed was discovered to be 200 rpm as a result of investigation as mentioned in Table 7.

Table 6. Agitation speed

S.No	Time (mins)	PH values	Initial concentration (mg/l)	Concentration of Adsorbent (g)	RPM	Final concentration	Efficiency
1	10	8	50	0.45	50	17	66
2	10	8	50	0.45	100	13	74
3	10	8	50	0.45	150	4	92
4	10	8	50	0.45	200	9	82

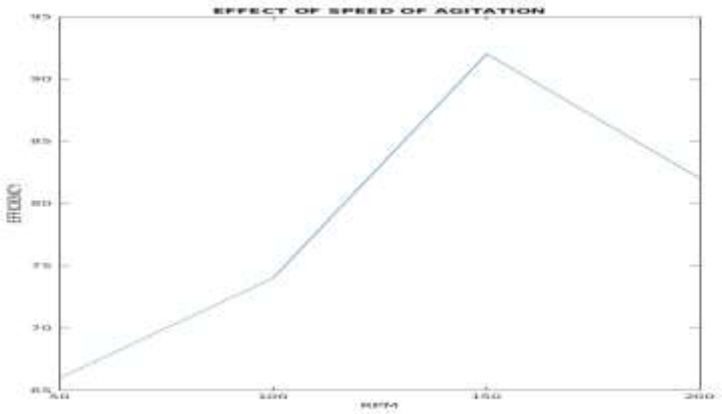

Figure 6. Effect of speed of Agitation

Table 7. Optimization of process of batch study parameters for mercury removal using carbonaceous nanoparticles

Sl.No	Parameters	Experimental Range	Optimized Value
1	Contact time	0-120 minutes	10 minutes
2	Dosage of Adsorbent (carbonaceous nanoparticles)	0.05-0.50g	0.40g
3	pH of Mercury Solution	1-14	8
4	Concentration of Mercury in solution	10-100mg/l	50mg/l
5	Agitation Speed	50-200rpm	200 rpm

5. Conclusion

- Discovered that clam shell nanoparticles, i.e. powdered clam seashells, are an excellent adsorbent in our experiment. adsorption of nickel ions was employed to remove Mercury ions from solution using clam shell nanoparticles made using Top-Down approach technique.
- Using nano-sized carbonaceous nanoparticles, mercury may be removed. When working with aqueous Mercury solution, absorptivity of flocs assessed by UV-Spectrophotometer reveals that procedure is efficient.
- Contact time, adsorbent dose, pH of solution, starting concentration of adsorbate, and agitation speed were all important operational factors in batch tests.

REFERENCES

1. Hassani A. H., Hossenzadeh, Torabifar B: "Investigation Of Using Fixed Activated Sludge System For Removing Heavy Metals (Cr, Ni And Ph) From Industrial Waste Water", Journal Of Environmental Studies, **36** (53), 22-24 (2010)
2. Lisha K. P., Anshup, Pradeep T: "Towards A Practical Solution For Removing Inorganic Nickel From Drinking Water Using Nanoparticles", Gold Bulletin, **42** (2) 144-152 (2009)
3. Ishanullah, Aamir Abbas, Adnan M. Al-Amer: "Heavy Metal Removal From Aqueous Solution By Advanced Carbon Nanotubes: Critical Review Of Adsorption Application", Separation And Purification Technology, 157, 141-161. (2016)
4. Donald Barceloux G. & Dr. Donald Barceloux: "Mercury Is A Silver- White Metal With Siderophilic Properties That Facilitate The Formation Of Nickel Iron Alloys", Journal Of Toxicology, 37(2), 239-258 (1999)
5. Anderson K. E., Nielsen G. D, Flyvholm M, Fregert S, Gruvberge B, "Nickel In Tap Water. Contact Dermatatis", Journal Of Toxicology, 37(2) 140-143 (1983)
6. Raman N. And Narayanan S., Impact Of Solid Waste Effect Of Ground Water And Soil Quality Nearer To Pallavaram Solid Waste Landfill Site In Chennai, (2008).
7. Shiva Kumar D. And Srikantaswami S: Advanced Journal Of Chemistry-Section A, 2012. Adsorption Separation Of Nickel From Wastewater In Industrial Area Mysore City, Karnataka, India, Int. J. Appli. And Engine.
8. Rather G., Adhikari T., And Chopra N., Management Of Nickel Contaminated Soil And Water Through The Use Of Carbon Nano Particles, J. Chem., Bio. Phy. Sci., 3(2),901-905, (2013)
9. Chompoonut C. And Chatpornklaikaew K., The Effect Of Kmno4, Edta And Cn On The Removal Of Heavy Metals From Chemical Laboratory Wastewater By International Research Journal Of Environment Sciences Issn2319–1414 3(10), 10 (2014)
10. Halstead R.L., Finn B. J. And Mclean A. J., Extractability Of Nickel Added To The Soils And Its Concentration In Plants, Cana. J. Soi. Sci, 49 (1969)
11. Mcgrath S.P., Heavy Metals In Soils (Ed: B. J. Alloway) 2nd Ed., Blackie Academic And Professional, London (1995)
12. Mcilveen W.D. And Negusanti J.J., Journals Of N In The Terrestrial Environment, Sci. Tot. Environ., 148 (1994)
13. Salt D.E., Phytoremediation Of Contaminated Soil And Water (Eds: N. Terry, G. Banuelos) Lewis Publishers, Boca Raton, Fl, 189-200 (2000)
14. Zhao J., Shi G. And Yuan Q., Polyamines Content And Physiological And Biochemical Responses To Ladder Concentration Of Nickel Stress In Hydrochories', Dubai (Bl.) Backer Leaves, Bio-Metals, 21, 665-674 (2008)
15. Berg T., The Release Of Nickel And Other Trace Elements From Electric Kettles And Coffee Machines, Food Addit. And Contami., 17(3), 189-196, (2000).
16. Allen H.E., Halley M.A. And Hass C.N., Chemical Composition Of Bottled Mineral Water Literature, Archives Of Envi. Heal., 44, 102-116 (1989).
17. Mohan, A , Vijayan, D.S. , Revathy, J., Parthiban, D., Varatharajan, R.: Evaluation Of The Impact Of Thermal Performance On Various Building Bricks And Blocks: A Review, Environmental Technology And Innovation, 2021, 23, 101577(2021)
18. Mcneely M.D., Nechay M.W. And Sunderman Jr F.W., Measurements Of Nickel In Serum And Urine As Indices Of Environmental Exposure To Nickel, Clini. Chem., 18, 992-995 (1972)
19. M. Tholkapiyan, A.Mohan, Vijayan.D.S: A Survey Of Recent Studies On Chlorophyll Variation In Indian Coastal Waters, Iop Conf. Series: Materials Science And Engineering 993 (2020) 012041, 1-6.
20. Bogner., Zarcinas B.A., Ishak C. F., Mclaughlin M. J. And Cozens G., Heavy Metals In Soils And Crops In Southeast Asia. 1. Peninsular Malaysia, Environ. Geoche. And Health, 26, 343-357 (2007).
21. Alloway B.J., Heavy Metal In Soils (Ed: B.J. Alloway) 2nd Ed., Blackie Academic And Professional, London, (1995)
22. Iarc Nickel And Nickel Compounds. In: Chromium, Nickel And Welding. Lyon, International Agency For Research On Cancer, 257-445 (Iarc Monographs On The Evaluation Of Carcinogenic Risks To Humans, 49 (1990)
23. Easton D.F., Nickel And Human Health: Current Perspectives (Eds: E. Nieboer, J. O. Nriagu,) John Wiley And Sons. New York (1992)
24. Gopalakrishnan, R., Mohan, A., Sankar, L. P., & Vijayan, D. S. (2020). Characterisation On Toughness Property Of Self-Compacting Fibre Reinforced Concrete. In Journal Of Environmental Protection And Ecology (Vol. 21, Issue 6, Pp. 2153–2163).
25. Lavanya Prabha, S., Dattatreya, J.K., Neelamegam, M., Seshagiri Rao, M.V., Investigation Of Bolted Rpc Plate Under Direct Tension, Journal Of Structural Engineering (Madras), 2009, 36(5), Pp. 333–341
26. Mohan, A., Tabish Hayat, M.: Characterization Of Mechanical Properties By Preferential Supplant Of Cement With Ggbs And Silica Fume In Concrete, Materials Today: Proceedings, 2020, 43, Pp. 1179–1189.
27. Dharmar, S., Gopalakrishnan, R., Mohan, A.: Environmental Effect Of Denitrification Of Structural Glass By Coating Tio2, Materials Today: Proceedings, 2020, 45, Pp. 6454–6458
28. Cheong,K.H.Andlee,S.C:"Strengthofretemperedconcrete",Acimaterialsj.90(3),203-206 (1993)
29. Kiruthika, C., Lavanya Prabha, S., Neelamegam, M.: Different Aspects Of Polyester Polymer Concrete For Sustainable Construction Materials Today: Proceedings, 2020, 43, Pp. 1622–1625
30. Prabha, S.L., Surendar, M., Neelamegam, M.: Experimental Investigation Of Eco-Friendly Mortar Using Industrial Wastes ,Journal Of Green Engineering, 2019, 9(4), Pp. 626–637
31. Panwar N.R., Saha J.K., Adhikari T., Kundu S., Biswas A.K., Rathore A., Ramnna S. And Shriwastawa S., Soil International Research Journal Of Environment Sciences Issn 2319–1414 Vol. 3(10), 94-98, 10 (2014) .

32. Menzel D.B., Pharmacokinetic "Modelling Of The Lung Burden From Repeated Inhalation Of Nickel Aerosols", Toxicology Letters, 38, 33-43 (1987).
33. Eskew D.L., Welch R.M. And Norvell W.A., Nickel, An Essential Micronutrient For Legumes And Possibly All Higher Plants, Science, 222, 621-623 (1983).