IRACST – Engineering Science and Technology: An International Journal (ESTIJ), ISSN: 2250-3498
Vol.6, No.4, July-August 2016

Feasibility Studies of Natural Adsorption Processes for Electroplating Wastewater

Chinmai K.
Department of Civil Engineering
University BDT College of Engineering
Davanagere, Karnataka, India

Dr. Lokeshappa B.
Associate Professor, Department of Civil Engineering
University BDT College of Engineering
Davanagere, Karnataka, India

Abstract— **Potential harmful metals toxicity present in industrial wastewater is hazard to environment from many decades, in countries like India, China and Thailand where effectiveness of removal process cost is major concern. The research is focussed on the effectiveness of three natural adsorbents viz. Natural Zeolite, Almond Shell and Oyster Shell, which are cheaply available in these countries for removal of toxic metals from electroplating wastewaters. Batch adsorption studies had been conducted on these adsorbents with Chromium, Iron and Zinc metals. The initial Characteristics of electroplating wastewater were Chromium-61 mg/L, Iron-1800 mg/L, Zinc-230 mg/L. Electroplating wastewater was treated using jar test apparatus and columns, using above natural adsorbents for 24 hours. After treating electroplating wastewater using Natural Zeolite, Almond Shell and Oyster Shell in Jar test experiment and results were observed for Natural Zeolite for Chromium, iron and zinc were 96.56%, 95.03%, 89.92% respectively, Almond Shell for Chromium, Iron and Zinc were 97.31%,96.94% and 96.46% respectively, Oyster Shell for Chromium, Iron and Zinc were 93.69%,94.22% and 88.99% respectively. After treating electroplating wastewater using Natural Zeolite, Almond Shell and Oyster Shell in Columns and results were observed for Natural Zeolite- Chromium, Iron and Zinc 97.83%, 92.46%, 96.42% respectively, Almond Shell for Chromium, Iron and Zinc 98.96%, 98.93% and 98.26% respectively, Oyster Shell for Chromium, Iron and Zinc were 95.79%, 96.87% and 93.61% respectively. In jar test removal efficiency iron and chromium is greater than zinc. In columns removal efficiency iron and chromium is greater than zinc. Compared to jar test, the removal efficiency of toxic metals is greater in column studies.**

Keywords- Electroplating Wastewater, Natural Adsorbents, Toxic Metals

I. INTRODUCTION

The electroplating industry has been playing a momentous role in development and growth of numerous metal manufacturing and other engineering industries. While electroplating operations is an essential and integral part of many engineering industries, there has also been a steady growth of independent and tiny - to medium-scale electroplating industries. The growth of these independent small scale electroplating industries may be attributable to the growth of light and medium engineering industries which found it more convenient and economical to have their products metal plated by independent electroplaters [10].In India, there are thousands of independent tiny to small scale units operating throughout the country both in organized and unorganized sector. The factors responsible for extensive pollution from these units include existence in very large number in a particular area, their sporadic distribution, small-scale operation, poor housekeeping, lack of space for installing waste treatment facility in view of their being located mostly in areas of high commercial activity or in a composite industrial complex and the high recurring costs of treatment of the waste water particularly for the tiny & small-scale units [10].Metals are finished for many reasons. A finish may be defined as any final operation applied to the surface of a metal article in order to lend it properties not possessed by the article in its "unfinished" form. The purposes of electroplating an article are for: Appearance, Protection, Special surface properties, or Engineering or mechanical properties.

There are lots of adsorbents that are effective for heavy metal removal from electroplating wastewater. The principal types of adsorbents are activated carbon, synthetic polymeric, and silica based adsorbents. Many of these adsorbents are not used widely because of their high cost. Studies has been done on natural wastes where materials such as cotton, walnut waste, peanut skin, sugarcane waste and onion hull, coffee grounds, tea leaves, apple wastes, wool fibre, bark and other cellulosic materials, cottonseed hulls, rice straw, soybean hulls and linseed flax have been studied. In general, they present good adsorption capacity. These unconventional natural adsorbents have advantages other than being abundant in nature. Most of them need less prior processing and are waste by-products from some other industry. So, they are an alternative to costlier adsorbents like activated carbon, or synthetic polymers [30]. In the present study, the natural adsorbents studied are as follows: Natural zeolite, Almond Shell and Oyster Shell.

II. MATERIALS AND METHODOLOGY

A. Preparation of Adsorbents

Natural Zeolite procured for the study was sieved at 75µm and packed in an air tight cover. The Almond Shells Were washed with distilled water and grinded using mixie (Konika, 500 watts). The Oyster Shells Were washed with distilled water

and grinded using mortar and pestle. The powder was sieved for particles less than 75µm and packed in an air tight cover.

B. Characteristics of Electroplating Wastewater

Electroplating Wastewater sample was collected from a local Electroplating industry which is located near Davanagere in Karnataka, and analyzed in Environmental Engineering laboratory, Department of Civil Engineering. The Initial Characteristics such as pH, chromium, iron and zinc using AAS.

C. Determination of Optimum Dosage of Natural Zeolite, Almond Shell and Oyster Shell from Synthetic Water

Optimum dosage of Natural Zeolite, Almond Shell and Oyster Shell are determined by using Jar Test Apparatus. Experiments were carried out in one litre capacity beakers for with known Chromium, Iron and Zinc Concentrations. Different amount of adsorbents (0.5, 1, 1.5, 2, 2.5and 3g) were added to 500mL of sample subjecting rapid rotation for 20 mins and slow rotation for 10 mins at 100 rpm for all the three adsorbents.

D. Determination of Optimum pH of Natural Zeolite, Almond Shell and Oyster Shell from Synthetic Water

The same procedure is repeated by varying the pH of the synthetic water and efficiency of the adsorbents in removal of Chromium, Iron and Zinc was found. The dosage taken is the optimum dosage for the three Adsorbents. The pH at which the efficiency is greater is taken as optimum pH

III. RESULTS

A. Characteristics of Electroplating Wastewater

Table 1 shows the Initial Characteristics of Electroplating wastewater.

TABLE I: INITIAL CHARACTERISTICS OF ELECTROPLATING WASTEWATER

Sl. No.	Parameter	Unit	Values
1	pH	-	1
2	Chromium	mg/L	61
3	Iron	mg/L	1800
4	Zinc	mg/L	230

B. Determination of Optimum Dosage of Natural Zeolite, Almond Shell and Oyster Shell from Synthetic Water

The Efficiency of Natural Zeolite in Removal of Chromium, Iron and Zinc are shown in the Table 2 and Figure 1.

TABLE II. EFFICIENCY OF NATURAL ZEOLITE IN REMOVAL OF CHROMIUM, IRON AND ZINC

Dosage(g)	Chromium (%)	Iron (%)	Zinc (%)
0.5	15.12	94.09	26.35
1	16.13	47.57	20.13
1.5	26.78	55.62	24.28
2	17.26	50.93	29.33
2.5	44.51	55.26	33.56
3	53.38	50.74	37.78

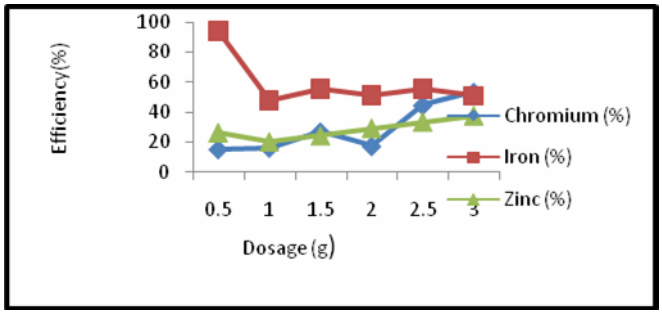

Figure 1. Efficiency of Natural Zeolite in Removal of Chromium, Iron and Zinc

From the Table 2 and Figure 1 it is known that natural zeolite has the highest efficiency of removing Chromium at dosage 3g, Iron at 0.5g and Zinc at 3g for 500 mL sample. The efficiency of Natural Zeolite for removing Chromium, Iron and Zinc are 53.38%, 94.09% and 37.78% respectively. The removal efficiency of Chromium at dosages 0.5g to 2.5g goes on fluctuating and has got higher efficiency at dosage 3g. For iron, higher efficiency is at dosage 0.5g and efficiency reduces comparatively at higher dosage. Zinc removal efficiency is gradual and has maximum at dosage at 3g.

The Efficiency of Almond Shell in Removal of Chromium, Iron and Zinc are shown in the Table 3 and Figure 2.

TABLE 3. EFFICIENCY OF ALMOND SHELL IN REMOVAL OF CHROMIUM, IRON AND ZINC

Dosage(g)	Chromium (%)	Iron (%)	Zinc (%)
0.5	53.96	81.04	27.84
1	87.09	90.92	29.82
1.5	32.09	56.34	37.66
2	31.26	44.24	18.64
2.5	16.49	35.62	15.41
3	7.26	98.32	32.067

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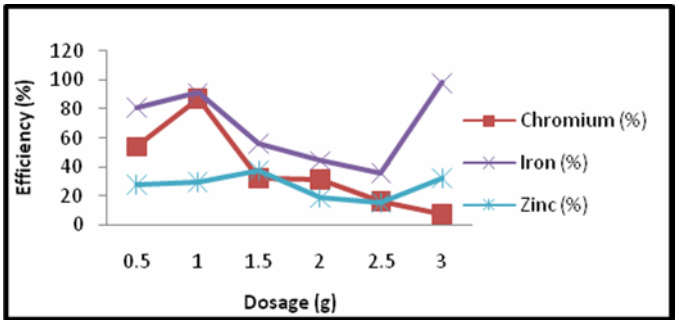

Figure 2. Efficiency of Almond Shell in Removal of Chromium, Iron and Zinc

From the Table 3 and Figure 2 it is known that Almond Shell has the highest efficiency of removing Chromium at dosage 1g, Iron at 1g and Zinc at 1.5g for 500 mL sample. The efficiency of Almond Shell for removing Chromium, Iron and Zinc are 87.09%, 90.92% and 37.66% respectively. The removal efficiency of chromium is high at 1g and decreases as dosage increases. Iron removal is high at dosage 1g and decreases as dosage increases and suddenly increases at dosage 3g which is 98.32%. For zinc, efficiency increases till dosage 1.5g and decreases for 2g and again increases at dosage 3g.

The Efficiency of Oyster Shell in Removal of Chromium, Iron and Zinc are shown in the Table 4 and Figure 3.

TABLE 4. EFFICIENCY OF OYSTER SHELL IN REMOVAL OF CHROMIUM, IRON AND ZINC

Dosage(g)	Chromium (%)	Iron (%)	Zinc (%)
0.5	13.17	93.06	27.61
1	12.32	76.32	28.25
1.5	28.06	92.73	19.10
2	16.46	91.21	27.34
2.5	28.33	85.79	29.00
3	49.55	65.06	36.57

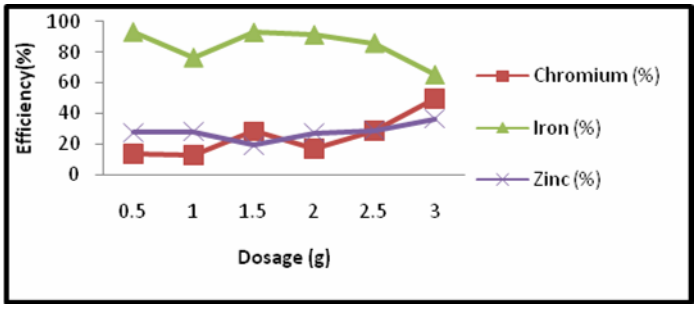

Figure 3. Efficiency of Oyster Shell in Removal of Chromium, Iron and Zinc

From the Table 4 and Figure 3 it is known that Oyster Shell has the highest efficiency of removing Chromium at dosage 3g, Iron at 0.5g and Zinc at 3g for 500 mL sample. The efficiency of Oyster Shell for removing Chromium, Iron and Zinc are 49.55%, 93.06% and 36.57% respectively. The removal efficiency of Chromium at dosages 0.5g to 2.5g goes on fluctuating and has got higher efficiency at dosage 3g. For iron, higher efficiency is at dosage 0.5g and efficiency reduces comparatively at higher dosage. Zinc removal efficiency is gradual and has maximum at dosage at 3g.

C. Determination of Optimum pH of Natural Zeolite, Almond Shell and Oyster Shell from Synthetic Water

The same procedure is repeated by varying the pH of the synthetic water and efficiency of the adsorbents in removal of Chromium, Iron and Zinc was found. The dosage taken is the optimum dosage for the three Adsorbents. The pH at which the efficiency is greater is taken as optimum pH. Table 5 and Figure 4 show the Efficiency of Natural Zeolite in Removing Chromium, Iron and Zinc at Different pH.

TABLE 5. EFFICIENCY OF NATURAL ZEOLITE IN REMOVING CHROMIUM, IRON AND ZINC AT DIFFERENT PH.

pH	Chromium (%)	Iron (%)	Zinc (%)
1	84.32	94.52	77.62
2	95.45	91.96	89.56
3	62.67	82.69	58.92
4	78.56	50.42	72.96
5	77.92	67.82	71.49
6	79.36	69.58	73.69
7	78.52	62.66	70.98
8	56.42	47.57	52.86
9	71.98	69.83	65.78
10	79.18	86.77	73.81

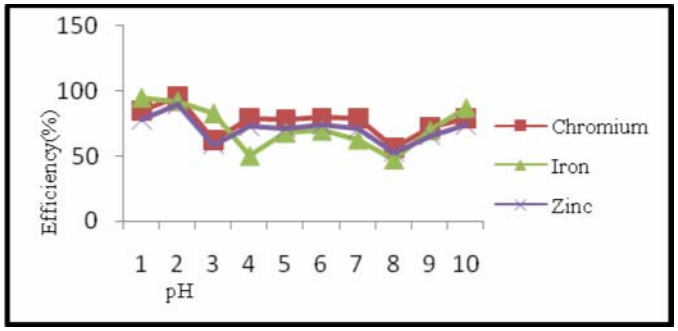

Figure 4. Efficiency of Natural Zeolite in Removing Chromium, Iron and Zinc at Different pH

From the experiment conducted for optimum pH, it was found that Chromium and Zinc are removed at greater efficiency at pH 2, and removal of Iron at 1 when Natural Zeolite was used as Adsorbent. The removal efficiency of chromium and zinc is high at pH 2 and decreases for higher pH and for iron optimum pH is at pH 1. Table 6 and Figure 5 show the

Efficiency of Almond Shell in Removing Chromium, Iron and Zinc at Different pH.

TABLE 6 .EFFICIENCY OF ALMOND SHELL IN REMOVING CHROMIUM, IRON AND ZINC AT DIFFERENT PH.

pH	Chromium (%)	Iron (%)	Zinc (%)
1	92.46	96.82	90.56
2	96.43	92.58	95.38
3	58.76	52.63	50.74
4	58.98	52.89	49.55
5	59.18	66.93	44.81
6	60.48	59.79	49.97
7	48.69	42.98	47.97
8	51.96	50.68	44.51
9	52.32	51.06	52.39
10	53.06	52.89	53.02

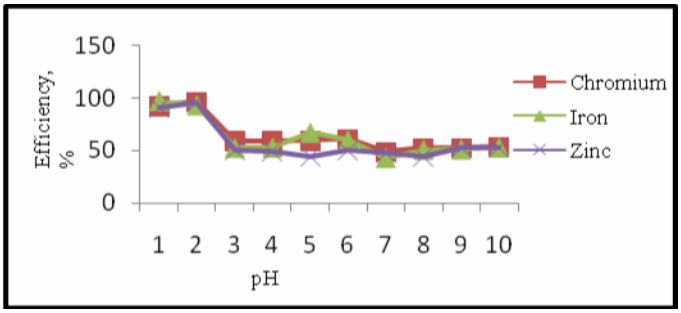

Figure 5. Efficiency of Almond Shell in Removing Chromium, Iron and Zinc at Different pH

From the experiment conducted for optimum pH, it was found that Chromium and Zinc are removed at greater efficiency at pH 2, and removal of Iron at 1 when Almond Shell was used as Adsorbent. The removal efficiency of chromium and zinc is high at pH 2 and decreases for higher pH and for iron optimum pH is at pH 1.

Table 7 and Figure 6 show the Efficiency of Almond Shell in Removing Chromium, Iron and Zinc at Different pH.

TABLE 4.7: EFFICIENCY OF OYSTER SHELL IN REMOVING CHROMIUM, IRON AND ZINC AT DIFFERENT PH.

pH	Chromium (%)	Iron (%)	Zinc (%)
1	82.47	93.01	75.40
2	93.56	89.48	87.78
3	62.98	80.73	56.77
4	76.98	48.96	70.90
5	75.68	65.12	69.45
6	77.23	68.81	71.82
7	76.09	61.92	69.49
8	54.69	44.28	50.32
9	70.80	67.23	62.89
10	77.06	84.92	71.23

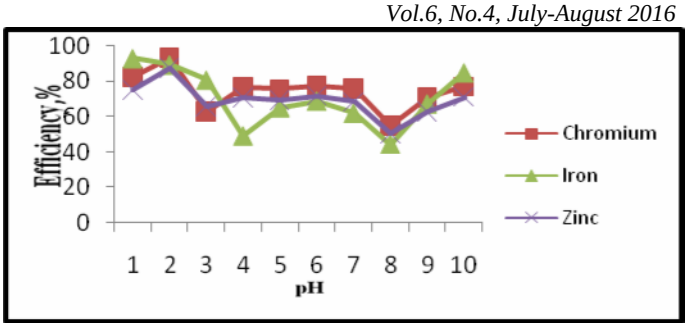

Figure 4.5: Efficiency of Oyster Shell in Removing Chromium, Iron and Zinc at Different pH

From the experiment conducted for optimum pH, it was found that Chromium and Zinc are removed at greater efficiency at pH 2, and removal of Iron at 1 when Oyster Shell was used as Adsorbent. The removal efficiency of chromium and zinc is high at pH 2 and decreases for higher pH and for iron optimum pH is at pH 1.

D. Treatment of Electroplating Wastewater in Jar Test Apparatus

The Electroplating Wastewater was treated for the removal of Chromium and Zinc at pH 2 and Iron at pH 1. The Dosage of Natural Zeolite and Oyster Shell used was 3g/500 mL and Dosage of Almond Shell was 1g/500mL. The Initial Concentration of Chromium, Iron and Zinc was 230mg/L, 1800mg/L and 61mg/L. Table 8 shows The Concentration of Chromium, Iron and Zinc after Treating with Natural Zeolite, Almond Shell and Oyster Shell in Jar Test Apparatus. Figure 7 shows The Concentration of Chromium, Iron and Zinc after Treating with Natural Zeolite, Almond Shell and Oyster Shell in Jar Test Apparatus.

TABLE 8. CONCENTRATION OF TOXIC METALS AFTER TREATING WITH NATURAL ADSORBENTS IN JAR TEST APPARATUS**.**

Natural Adsorbents	Chromium(%)	Iron(%)	Zinc(%)
Natural Zeolite	96.56	95.03	89.92
Almond Shell	97.31	96.94	96.46
Oyster Shell	93.69	94.22	88.99

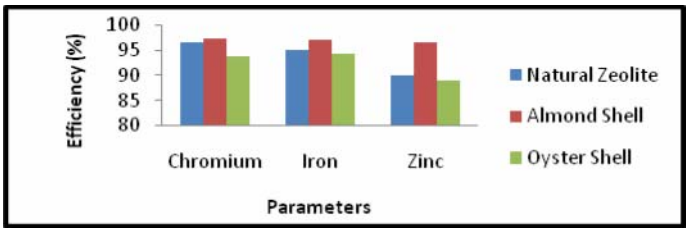

Figure 7. The Concentration of Chromium, Iron and Zinc after Treating with Natural Zeolite, Almond Shell and Oyster Shell in Jar Test Apparatus.

E. Treatment of Electroplating Wastewater using Columns

The Electroplating Wasteter was treated using Natural Zeolite, Almond Shell and Oyster Shell at pH 2 for Chromium and Zinc and AT pH 1 for Iron with the depth of 10cm. The Column used was of Diameter 1.8cm and height 30 cm. Table 9 shows The Concentration of Chromium, Iron and Zinc after Treating with Natural Zeolite, Almond Shell and Oyster Shell in Columns. Figure 8 shows The Concentration of Chromium, Iron and Zinc after Treating with Natural Zeolite, Almond Shell and Oyster Shell in Columns.

TABLE 9. THE CONCENTRATION OF TOXIC METALS AFTER TREATING WITH NATURAL ADSORBENTS IN COLUMNS.

Natural Adsorbents	Chromium(%)	Iron(%)	Zinc(%)
Natural Zeolite	97.83	92.46	96.42
Almond Shell	98.96	98.93	98.26
Oyster Shell	95.79	96.87	93.61

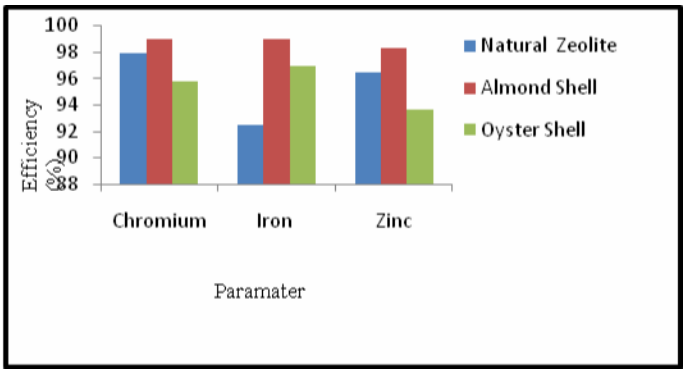

Figure 4.8: The Concentration of Chromium, Iron and Zinc after Treating with Natural Zeolite, Almond Shell and Oyster Shell in Columns.

IV. SUMMARY AND CONCLUSIONS

A. SUMMARY

To meet the goal of work, the accompanying rundowns are drawn from the test study led on treatment of electroplating wastewater utilizing natural zeolite, almond shell and oyster shell as adsorbents. Electroplating wastewater had the characteristics as follows: pH was 1, chromium-61 mg/L, iron-1800 mg/L, zinc- 230 mg/L. From the experiment, the optimum dosage of natural adsorbents were found out and they are as follows: natural zeolite-0.5 g for iron and 3g for chromium and zinc, almond shell-1g for chromium and iron and 1.5 for zinc, oyster shell-3g for chromium and zinc and 0.5 g for iron. The optimum pH of Natural zeolite, almond shell and oyster shell were found to be 1 and 2. Using Optimum dosages and optimum pH of all the three natural adsorbents, raw electroplating wastewater was treated in jar test apparatus and efficiency obtained was; for natural zeolite-chromium removal was 96.56%, iron removal was 95.03% and for zinc it was 89.92% respectively. When almond shell was used chromium, iron and zinc removal efficiency were 97.31%, 96.94% and 96.46% respectively. Removal efficiency of chromium, iron and zinc were 93.69%, 94.22% and 88.99% respectively when oyster shell was used. The raw electroplating wastewater was also treated using columns and efficiencies were found to be and; for natural zeolite-chromium removal was 97.83%, iron removal was 92.46% and for zinc it was 96.42% respectively. When almond shell was used chromium, iron and zinc removal efficiency were 98.96%, 98.93% and 98.26% respectively. Removal efficiency of chromium, iron and zinc were 95.79%, 96.87% and 93.61% respectively when oyster shell was used.

B. CONCLUSIONS

Taking into account the above finding the accompanying conclusions can be drawn;

- Electroplating wastewater is exceedingly dirtied wastewater and Pollution brought about by crude wastewater arranged to closest water bodies or land is a standout amongst the most basic natural issues.
- Natural Adsorbents have bright future in eradicating problems related to wastewater treatment rather than chemical Adsorbents. Formation of sludge is less after treatments of wastewater using natural adsorbents
- They are eco-friendly and biodegradable. Locally available renewable natural resource natural zeolite, almond shell and oyster Shell showed an effective role in water and wastewater treatment.
- Column give higher efficiency compared to jar test experiments in removing toxic metals

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AUTHORS PROFILE

First Author: Chinmai K. graduated in B. E. Environmental Engineering from Vidyavardhaka College of Engineering, Mysore, Karnataka, India

in 2014 and persuing Post Graduation(M. Tech) in Environmental Engineering from University BDT College of Engineering, Davanagere, Karnataka, India(2016).

Second Author: Lokeshappa B. graduated in B.E. Civil Engineering from University BDT College of Engineering Davanagere, Karnataka, India in 2000 and Post Graduation(M.Tech) in Industrial Pollution Control from National Institute of Technology, Karnataka, Surathkal, India in 2003 and Ph.D from Indian Institute of Technology Bombay in 2012.

Presently he is working as a Associate Professor in Department of Studies in Civil Engineering at University BDT College of Engineering, Davanagere, Karnataka, India since from 2006.

His main research interests are Solid Waste Management, Environmenatal Impact Assesment, Water and Wastewater Treatment Options, Environmental System Modeling and Appication of GIS in Environmental System Modeling and Application of GIS in Environmet. He has 10 publications in journals and 15 publications in conferences to his credit.