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# Statistical Analysis of Heavy Metals In Water, Soils and Sediments Due to Municipal Solid Waste Disposal in to Water Body of River Krishna Near Jamkhandi of Bagalkot District, Karnataka State, India

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## Abstract

Soil concentration is one of the serious environmental problems. Soil contaminants have different physico–chemical properties, which influence the geochemical reactions included in the soils and may change environmental behavior. In the present investigation statistical analysis of soil contaminated with Organic Carbon, heavy metals, secondary nutrients and major nutrients were carried out using so far reported standard methods. The soils and sediments of various locations of the river near dumpsite area were analyzed quantitatively for the presence of Zinc, Copper, Iron, Manganese, Molybdenum and Boron using Atomic Absorption Spectrophotometer. Available Nitrogen and Total Nitrogen in soil and sediments were analyzed by Nitrogen analyzer, Sodium, Potassium was measured using Flame photometer. The presence of Sulphur in soils and sediments were analyzed by using visible Spectrophotometer. pH, TDS, EC, values were recorded using respective instruments and some secondary nutrients were analyzed by Titrometric methods.

**Keywords:** Soils, Sediments, Heavy metals, Secondary and Major nutrients

## Contents



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## 1. Introduction

Bagalkot district in the Northern part of Karnataka state frequently affected by flood and cultivated lands are completely became unfertile due to the heavy irrigation, it leads the major damages on vegetations. The fertility of lands totally under declination because of flood and heavy irrigation. River Krishna is life line for agriculture development and sugar Industries. In the location of Jamkhandi more than 8 sugar industries are cited, each discharging its characteristic range of effluents containing heavy metals into the river Krishna directly or indirectly. River Krishna acts as a reservoir receiving effluents daily from drainages through different parts of the Municipal towns such as high population growth accompanied by intensive Urbanization and Industrialization. Increased in industrial activities and higher exploitations of natural resources including cultivable land have caused pollution increase. It is reported that river water contamination is increasing due to anthropogenic activities like disposal of domestic waste; it is the major threats to water resources[1-5]. It has received little attention in heavy metal studies in soils and sediments of cultivated lands relative to the river Krishna known widely as sink for the metals from various sugar industries and municipal solid waste disposal spread across the river in the area of Bagalkot district.

There has been a steady increase in discharges that reaches the aquatic environment from industries [6], Sugar processing plant also produces much finally divided organic material as waste product. Although some industrial process large amount of organic materials is also released into the water body, which is broken down easily by bacteria activities resulting in the reduction of oxygen level or even anaerobic condition in the vicinity of an effluent [**7]**. An addition to direct deflection of oxygen, the decomposition of large quantities of organic material in the water produces inorganic nutrients such as Ammonia, Nitrate and Phosphorus. These enrich the water considerably and give rise to dense algae growth which can cause the fluctuations in oxygen demand. The excessive organic load can also cause a decline in water quality. Soils and sediments have been reported to form the major deposition of heavy metals in various concentrations. The presence of metal pollutant in water is known to disturb the delicate balance of the aquatic ecosystem. More studies in the distribution of heavy metals in water bodies reveal that the levels of heavy metals in the bottom sediment are usually higher than in the water columns which show that soils and sediments acts as sink for heavy metals [8].

The present work possesses greater importance towards determining the distribution of heavy metal in soil and sediments of cultivated lands and River Krishna water bodies, assessing the influence of Municipal solid wastes discharged in to the water body and discharge of effluents through the industries. The same water is used for the agricultural activities throughout the season, it should be studied that the trace and heavy metals present in soils and sediments make the crops and their yields critical.

## 2. Experimental

Water samples were collected from various locations of river bodies. Soil samples were collected from study sites into pre-cleaned polythene bags. Bottom sediments from each study areas were collected into clean and dry polythene bags. All the reagents used were of analytical grade, deionized water (18 mega ohm resistivity) prepared from Millipore Mili-Q water purification system, USA, was used throughout. Hydrochloric acid (Merck) 40% Ultra pure. Surface water samples were collected using plastic containers. 5 ml of Concentrated Hydrochloric acid was added to 250 ml of water samples and evaporated to 25 ml. the concentrate was transferred to 50 ml flask and diluted up the mark with the distilled water. Metal contents were determined using Atomic Absorption Spectrometer (AAS- Eli co) to determine the presence of metals such as Cu, Zn, Ni, Co, Fe, Boron and Molybdenum. 5 gms of soils and sediments samples were taken into 150 ml conical flasks separately, 50 ml of 0.1 M HCl was added and flasks were kept on shaker for 30 minutes. The contents were filtered in to 50 ml standard flask and made up to mark with 0.1 M HCl for determination of micronutrients using Atomic Absorption Spectrophotometer (AAS).

## 3. Results and Discussion

The analytical data of Physico-Chemical parameters of River water around the Municipal waste disposal point (dumpsite) near twin cities like Rabakavi and Banahatti, the data of upstream, disposal point and downstream are shown in **Table 1**. The main descriptive statistics for River Krishna water samples at various locations is given in **Table 2**, all values were compared with the WHO, ISI and Bureau of Standards.

**Surface water pH:** The statistical analysis of water samples collected at upstream of River Krishna near the twin cities seasonally indicates the pH 7.10 were as at Municipal discharge site pH was found to be 7.48. The down stream water pH exhibited variation within a same range in between 7.28 to 7.11 the pH values go on decreasing throughout downstream due to the natural purification upto 5.0 kms. The highest pH 7.48 was recorded at Municipal disposal point and lowest value 7.11 was recorded at downstream spot S6. The gradual lowering in pH values clearly confirms the phenomenon of acidification of River water in the study area.

**Dissolved heavy metals:** The order of dissolved heavy metals in River water at Municipal dumpsite is Fe> Zn> Mn> Cu. Dissolved Zn at disposal point found to be 55.8 ppb, Cu ranged from 0.392ppb to 0.301 ppb, during the study period the value of dissolved Mn ranged from 39.18 ppb to 11.01 ppb. Whereas Fe found in higher concentration ranges in between 495. Ppb to 450.0 ppb. Electrical Conductivity (EC): the electrical conductivity of the samples were also in accordance with TDS values indicating that the major cations like Na , Ca, Mg and Major anions like Cl' , $HCO_3$', $CO_3$'', $SO_4$'' are present in maximum amounts at Municipal dumpsite.

The Sodium concentration in all samples is within the permissible limit (200 ppm) as per WHO standards. The Calcium concentration at dumpsite is above the permissible limit (75 ppm) as per BIS legal limit which may be due to Geogenic and Anthropogenic sources. Sulphate is found to be in the range of 61.0 ppm to 100.0 ppm, all samples found within the permissible limits (150.0 ppm) as per BIS standard. The highest value of Chloride which exceeds the limit (250.0 ppm) as per BIS at the Municipal discharging point into the River water. The concentrations of CO3'' and HCO3'' leads positive loading to water body at Municipal disposal site. The Maximum and minimum concentrations of metals along with their average values were listed in Table 2, is attributed to anthropogenic influence as these metals have migrated from municipal dumpsite.

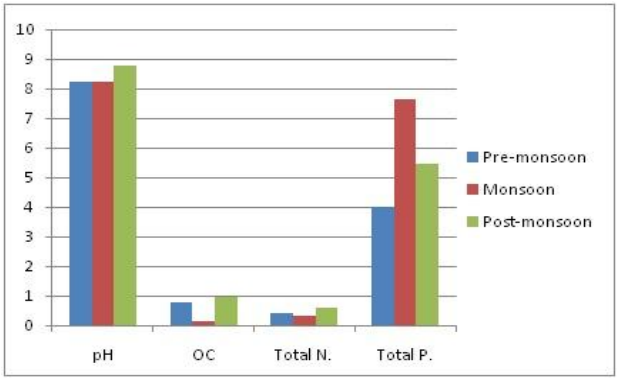


**Figure 1:** Seasonal Variation of Physico-Chemical & Major Nutrients Soil samples.

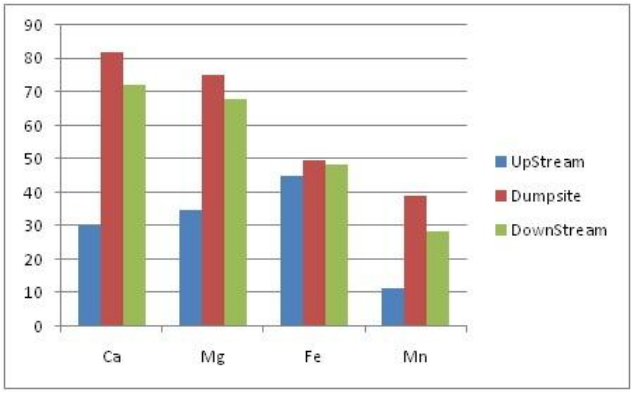


**Figure 2:** Seasonal Variation of Physico-Chemical & Major Nutrients in Sediment samples.

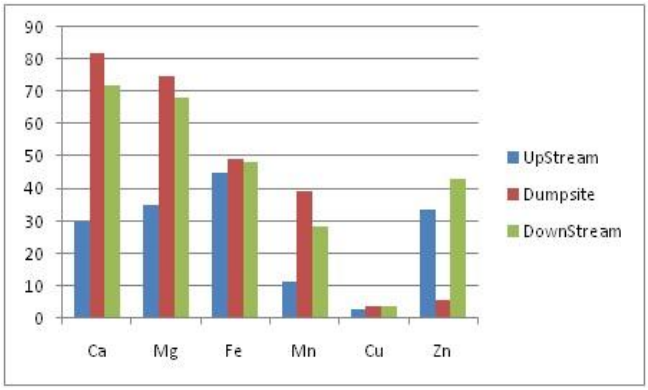


**Figure 3:** Seasonal Variation of Micro-Nutrients in Soil Samples

**Table 1:** Analytical Results of River Water at Different Locations.
(Upstream, Municipal dumpsite and Downstream water flow)

| Parameter | Unit | Upstream | dumpsite | Down Stream $SpotS_1$ 0.5 km | Down Stream $SpotS_2$ 1 km | Down Stream $SpotS_3$ 2 km | Down Stream $SpotS_4$ 3 km | Down Stream $SpotS_5$ 4 km | Down Stream $SpotS_6$ 5 km |
|---|---|---|---|---|---|---|---|---|---|
| pH | --- | 7.10 | 7.48 | 7.35 | 7.28 | 7.21 | 7.18 | 7.12 | 7.11 |
| EC | ds/m | 1.1 | 1.9 | 1.6 | 1.5 | 1.4 | 1.3 | 1.2 | 1.2 |
| TDS | Ppm | 700 | 1280 | 1008 | 992 | 918 | 865 | 794 | 710 |
| TA | Ppm | 432 | 805.8 | 556 | 524.4 | 503 | 484.8 | 469.1 | 441.1 |
| TH | Ppm | 218.5 | 542.5 | 486 | 367.4 | 336.5 | 284.3 | 237.4 | 222.6 |
| Na | Ppm | 1.6 | 2.4 | 1.9 | 1.9 | 1.8 | 1.8 | 1.9 | 1.6 |
| K | Ppm | 0.514 | 0.702 | 0.692 | 0.612 | 0.592 | 0.561 | 0.531 | 0.515 |
| DO | Ppm | 6.4 | 6.7 | 6.6 | 6.5 | 6.5 | 6.4 | 6.4 | 6.4 |
| CO3'' | Ppm | 20 | 38 | 35 | 34 | 30 | 28 | 26 | 21 |
| HCO3'' | Ppm | 140 | 260 | 165 | 154 | 152 | 148 | 145 | 142 |
| Cl' | Ppm | 105 | 260 | 130 | 128 | 121 | 118 | 112 | 110 |
| NO3' | Ppm | 49 | 72 | 60.2 | 60 | 56 | 52 | 50 | 49 |
| SO4'' | Ppm | 60 | 100 | 78 | 74 | 72 | 70 | 65 | 61 |
| Ca | Ppm | 30 | 82 | 72 | 42 | 41 | 35 | 31 | 30 |
| Mg | Ppm | 35 | 75 | 68 | 64 | 52 | 48 | 39 | 36 |
| Fe | Ppb | 452 | 495 | 483 | 472 | 463 | 460 | 453 | 450 |
| Mn | Ppb | 11.46 | 39.18 | 28.45 | 28.01 | 26.05 | 18.14 | 14.42 | 11.01 |
| Cu | Ppb | 0.294 | 0.392 | 0.382 | 0.378 | 0.365 | 0.352 | 0.312 | 0.301 |
| Zn | ppb | 33.70 | 55.80 | 43.20 | 40.30 | 39.12 | 37.15 | 35.12 | 34.01 |

**Table 2:** Statistical Analysis Report of River Water Before and After Dumpsite Area near Rabakavi and Banahatti Towns.

| **Parameter** | **Unit** | **Means** | **Meddle** | **Minimum** | **Maximum** |
|---|---|---|---|---|---|
| pH | --- | 7.22875 | 7.28 | 7.10 | 7.48 |
| EC | ds/m | 1.4 | 1.5 | 1.1 | 1.9 |
| TDS | Ppm | 908.3750 | 1008 | 7.00 | 1280 |
| TA | Ppm | 527.025 | 556 | 432 | 805.8 |
| TH | Ppm | 336.900 | 367.4 | 218.5 | 542.5 |
| Na | Ppm | 1.8625 | 1.9 | 1.6 | 2.4 |
| K | Ppm | 0.5899 | 0.612 | 0.514 | 0.702 |
| DO | Ppm | 6.4875 | 6.55 | 6.4 | 6.7 |
| CO3'' | Ppm | 29 | 28 | 20 | 38 |
| HCO3'' | Ppm | 163.250 | 165 | 140 | 260 |
| Cl' | Ppm | 135.500 | 130 | 105 | 260 |
| NO3' | Ppm | 56.025 | 60.2 | 49 | 72 |
| SO4'' | Ppm | 72.500 | 78 | 60 | 100 |
| Ca | Ppm | 45.375 | 52 | 30 | 82 |
| Mg | Ppm | 52.125 | 52 | 35 | 75 |
| Fe | Ppb | 466.000 | 472 | 450 | 495 |
| Mn | Ppb | 22.090 | 26.05 | 11.01 | 39.18 |
| Cu | Ppb | .0347 | 0.352 | 0.294 | 0.392 |
| Zn | ppb | 39.800 | 43.20 | 33.70 | 55.80 |

All metals concentration was found within the permissible limit in water samples at different locations. Especially with reference to Cu, Fe, Mn, and Zn were found in very abnormal average concentrations. The concentration of Cu (0.347 ppb), Fe (466.0 ppb), Mn (22.09 ppb) and Zn (39.8 ppb) on average can be attributed to anthropogenic source. The metals Copper, Iron, Manganese and Zinc are characterized as undesirable metals in drinking water [**9]**. The heavy metals may be absorbed by the soils and sediments or by the organic matters in the soils.

**Soil and Sediments Analysis:**

In soils and sediments the variation of biologically available metal (Micro nutrients) such as Fe, Mn, Zn, Cu, boron and Molybdenum exhibited a decreasing trend in soil samples as compared to the sediment compartment. Fe ranges in between 0.81 ppm to 1.85 ppm, minimum and maximum during post monsoon and monsoon seasons in soil samples respectively, but in case of sediment samples ranges in between 3.91 ppm to 4.12 ppm. Hence, Fe in sediments were found normal limit as prescribed by BIS standards. In case of Mn, the values ranged in between 0.10 ppm to 0.65 ppm in selected samples, such soils were found more critical for crops and plants. The same micro nutrients in sediments samples ranged in between 1.124 ppm to 1.273 ppm, Mn was within prescribed limit as per the BIS legal limit.

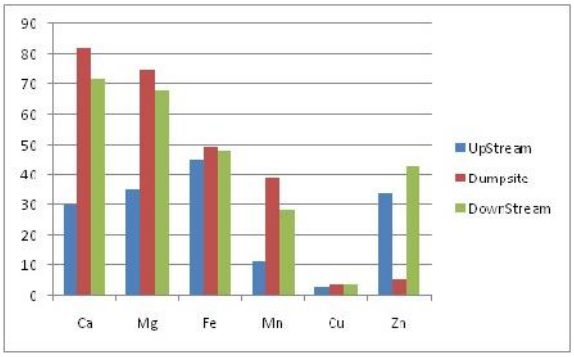


**Figure 4:** Seasonal Variation of Micro-Nutrients in Sediment Samples

**Table 3:** Soil and Sediments Analysis Report Seasonally

| Paramter | Unit | Soil Analysis | | | Sediment Analysis | | | Limit |
|---|---|---|---|---|---|---|---|---|
| | | Pre-Monsoon | Monsoon | Post-Monsoon | Pre-Monsoon | Monsoon | Post-Monsoon | |
| Bulk Density | g/cc | 1.13 | 1.12 | 1.10 | 1.10 | 1.08 | 1.09 | --- |
| Water Holding Capacity | % | 58 | 56 | 57 | 56 | 54 | 52 | --- |
| Texture | --- | Loam | Sandy | Clay loam | Black Clay | Black Clay | Black Clay | --- |
| pH | --- | 8.23 | 8.31 | 8.76 | 8.34 | 8.68 | 8.57 | 6.5-7.5 |
| EC | Ds/m | 2.288 | 1.308 | 1.274 | 2.370 | 2.320 | 2.290 | <1 |
| Na | % | 4.068 | 3.814 | 1.328 | 0.728 | 0.732 | 0.726 | <0.1 |
| CaCO3 | --- | Low | Medium | Low | Medium | Medium | Medium | --- |
| OC | % | 0.79 | 0.15 | 0.97 | 0.41 | 0.39 | 0.46 | 0.5-0.75 |
| Avail.N | Kg/h | 175.6 | 213.2 | 238.2 | 188 | 175 | 182 | 250-280 |
| Total.N | % | 0.4 | 0.3 | 0.6 | 0.0042 | 0.0046 | 0.0042 | 0.03-0.06 |
| Avail.P | Kg/h | 4.00 | 7.65 | 5.46 | 67.28 | 67.90 | 63.40 | 20-60 |
| Avail.K | Kg/h | 372.9 | 170.2 | 239.7 | 453.1 | 498.7 | 418.5 | 250-300 |
| Ca | % | 0.88 | 0.88 | 0.88 | 1.88 | 1.72 | 1.88 | <1 |
| Mg | % | 0.32 | 0.55 | 0.33 | 0.292 | 0.298 | 0.292 | <0.5 |
| SO4'' | Ppm | 4.87 | 5.71 | 3.62 | 34.21 | 33.62 | 34.72 | 10-20 |
| Fe | Ppm | 1.78 | 1.85 | 0.81 | 4.12 | 3.91 | 3.98 | Min.4.50 |
| Mn | Ppm | 0.10 | 0.65 | 0.58 | 1.273 | 1.273 | 1.124 | Min.2.00 |
| Zn | Ppm | 2.81 | 1.80 | 1.28 | 0.812 | 0.673 | 0.612 | Min.0.75 |
| Cu | Ppm | 1.78 | 0.68 | 2.68 | 3.280 | 2.731 | 2.728 | Min.0.60 |
| Boron | Ppm | 0.74 | 0.78 | 0.31 | 0.18 | 0.12 | 0.12 | Min.0.50 |
| Mo | ppm | 0.05 | 0.04 | 0.08 | 0.08 | 0.04 | 0.18 | Min.0.05-0.2 |

Copper found more than the legal limit in both soils and sediments samples, Cu ranges in between 0.68 ppm to 2.68 ppm in soil samples, where as in sediment samples Copper ranged in between 2.728 ppm to 3.280 ppm found more than normal limit (0.60 ppm) as per WHO / BIS standards. The micro nutrients Boron and Molybdenum were found in normal permissible limits as prescribe by the international standards. The another important micro nutrient Zinc in

sediment samples found in normal permissible limit, but maximum amount of Zn concentration in soil samples of study area. In general the deficiency of micro nutrients (Heavy metals) were found in soil samples, it was due to heavy irrigation and effect of flood during the monitoring period.

The River sediments found agreeable amount of micronutrients and found more fertile than soil samples of cultivated lands. It is also found that the order of biological available heavy metals (micronutrients) in sediments (Fe > Cu > Zn < Mn) is similar to that of dissolved heavy metals in River Krishna water samples were collected at the Municipal dumpsite of Rabakavi and Banahatti towns of Bagalkot district. The soil and sediment analysis results reported in **Table 3.** Table 4 reports the seasonal statistical correlation between Soils and Sediments from different locations of study area. The micro nutrients such as Boron and Zinc found deficiency in sediment samples during all seasons, where as soil samples possessed Zinc and Boron more than prescribed limits. The deficiency of Zn and Boron makes land unfertile.

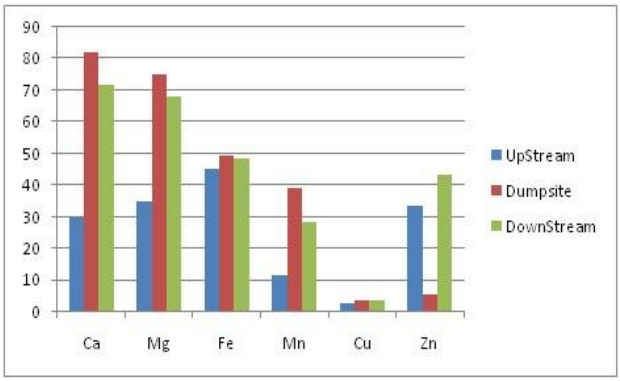


**Figure 5:** Trace & Heavy Elements in Water Samples at of River Krishna Near Rabakavi & Banahatti Locations.

**Table 4:** Statistical Co – Relation between Soils and Sediment samples from Study Area.

| Parameter | Unit | Mean | Middle | Minimum | Maximum | Legal limit |
|---|---|---|---|---|---|---|
| Bulk Density | g/cc | 0.362 | 1.10 | 1.08 | 1.13 | --- |
| Water Holding Capacity | % | 55.50 | 56 | 52 | 58 | --- |
| Texture | - | 8.482 | --- | --- | --- | --- |
| pH | - | 1.9767 | 8.57 | 8.23 | 8.76 | 6.5-7.5 |
| EC | Ds/m | 2.9883 | 1.822 | 1.274 | 2.370 | <1 |
| Na | % | --- | 3.814 | 0.726 | 4.068 | <0.1 |
| CaCO3 | - | 0.5283 | --- | --- | --- | --- |
| OC | % | 195.333 | 0.79 | 0.15 | 0.97 | 0.5-0.75 |
| Avail.N | Kg/h | 0.2188 | 213.2 | 175 | 238.2 | 250-280 |
| Total.N | % | 35.948 | 0.300 | 0.0042 | 0.6 | 0.03-0.06 |
| Avail.P | Kg/h | 358.850 | 63.40 | 4.00 | 67.90 | 20-60 |
| Avail.K | Kg/h | 1.3533 | 372.9 | 170.2 | 498.7 | 250-300 |
| Ca | % | 0.347 | 1.72 | 0.88 | 1.88 | <1 |
| Mg | % | 19.4583 | 0.298 | 0.292 | 0.550 | <0.5 |
| SO4'' | Ppm | 2.7417 | 33.62 | 3.62 | 34.72 | 10-20 |
| Fe | Ppm | 0.8333 | 3.91 | 0.81 | 4.12 | Min.4.50 |
| Mn | Ppm | 1.3312 | 1.124 | 0.10 | 1.273 | Min.2.00 |
| Zn | Ppm | 2.3132 | 1.28 | 0.612 | 2.81 | Min.0.75 |
| Cu | Ppm | 2.3132 | 1.98 | 0.68 | 3.280 | Min.0.60 |
| Boron | Ppm | 0.375 | 0.31 | 0.12 | 0.78 | Min.0.50 |
| Mo | ppm | 0.0783 | 0.08 | 0.04 | 0.18 | Min.0.05-0.2 |

## 4. Conclusion

The present investigation work on River Krishna water pollution due to Municipal sewage waste dumpsite at Rabakavi and Banahatti. The study reveals that from the values of River water parameters near Municipal waste disposal point were polluted as compared to the samples collected from upstream and different spots ($S_1$ to $S_6$) of downstream flow of water. The River water found polluted to maximum extent at Municipal solid waste disposal

point, due to direct dumping of drainage waste in to the water body of the River Krishna near the twin cities of Jamkhandi taluk of Bagalkot district. The seasonal variation of Physico-Chemical & Major Nutrients in soil and Sediment samples were shown in Figure 1 and Figure 2. The Figure 3 and Figure 4 Indicate the seasonal variation of Micro-nutrients in the soil and sediment samples from the different locations during the monitoring period. The Organic Carbon and total Nitrogen in soil samples were found in lesser quantity during monsoon, this is due to natural washing by heavy rains. Trace & Heavy Elements present in Water Samples at upstream, dumpsite and down streams of River Krishna near Rabakavi & Banahatti twin cities.

## 5. Acknowledgment

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