International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 09 Issue: 07 | July 2022 www.irjet.net p-ISSN: 2395-0072

Assessment of Heavy Metal Toxicity in Ground Water and Reuse of Lathe Waste

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Abstract - *Metal chips are generated during the cutting, milling and turning process as a side effect of manufacturing elements. These wastes represent about 3–5% by weight of metal casting. This project is aimed to study the effect caused on water bodies nearby the metal industries in Kulapully, a small town in Palakkad district. As a solution to minimize the waste generation, this metal chips can be used as replacement of aggregates or steel fibres in concrete. The sample required for the study were collected from both borewell and openwell. The metal chips that are directly released into the environment may also pollute water sources and soil. Therefore the metal waste is added as a replacement of aggregates in concrete. The water samples collected and water quality tests such as determination of pH, Total Dissolved Solids, Total Dissolved Iron content, Biochemical Oxygen Demand, Chemical Oxygen Demand, Total Hardness, Chlorides, Alkalinity, Flouride, Nitrate, Manganese, Sulphate, Sulphide and Turbidity was tested in a near by laboratory. The results of the groundwater quality of the present study are compared and discussed with the highest desirable limits. It was observed that the iron content and total hardness was higher than the desirable limit. While comparing the two sources of water it can be concluded that water sample collected from borewell shows a higher variation in the values as compared to sample collected from open well.*

Key Words: Metal chips, Aggregates, Total Dissolved Solids, Biochemical Oxygen Demand, Chemical Oxygen Demand.

1.INTRODUCTION

Drinking water is a very important need of the people to maintain the hydration of the human body. Because of scanty rainfall and many fold uses of water (drinking, irrigation and industrial purposes), groundwater table has decreased. All over the world, water has been contaminated regularly due to manmade and natural sources. Most of the households use domestic sand filters to treat groundwater before drinking, to remove iron and odors. These simple sand filters also remove iron content and hardness, with an average reduction rate of 80%. The existence of trace metals in aquatic environments often led to serious concerns about their influence on plant and animal life.

The site selected for the present study is surrounded by many small scale metal industries. The widespread use of steel products in the industry results in energy consumption , CO_2 emission and production of steel waste in various amounts and size .Some steel waste is recycled. Due to contamination of the chip surface with oils or other coolants during the machining process, the storage of this waste has a negative impact on the environment, and its cleaning generates additional costs. In addition, the generated chips can have different properties due to different types of materials being processed. In literature it can be found that metal chips used in concrete mix are classified by other scientists as a replacement for aggregate or steel fibers.

1.1 Objectives

- The aim of the study is to evaluate the properties of drinking water sample collected from both bore well and open well from the nearby areas of the metal industries.
- The presence of different contaminants are studied by conducting laboratory experiments.
- The obtained values are compared with the standard values.
- Contamination caused due to the metal exposure can be reduced to a certain amount by installing filters.
- The otherway suggested is to reuse metal waste in cement concrete.

2. LITERATURE REVIEW

Anita Singh et al [1] conducted a study on waste water from Dinapur sewage treatment plant used for irrigating vegetable plots at Varanasi city. They quantified the concentrations of heavy metals, viz. Cd, Cr, Cu, Ni, Pb and Zn in soil, vegetables and the waste water used for irrigation. The waste water used for irrigation had the highest concentration of Zn followed by Pb, Cr, Ni, Cu and Cd.,Heavy metal concentrations varied among the test vegetables, which reflect the differences in their uptake capabilities and their further translocation to edible portion of the plants. Percent contribution to daily intake rate of Cu, Ni, Pb and Cr was higher by fruit vegetables, whereas that of Cd and Zn was higher by leafy vegetables. They made a conclusion that waste water treatment technology should involve steps to remove heavy metals causing risk to human health.Arjun

Lakshman et al [2] collected a total of 382 groundwater samples from 58 villages and analyzed for HMs and Sr by inductively coupled plasma mass spectrometer. The average concentrations of HMs and Sr in water was in the order of strontium (Sr) > arsenic (As) > chromium (Cr) > lead (Pb) > mercury (Hg) > cadmium (Cd). Out of 58 villages, 21, 37, 35, 35, 35 and 39 villages had Cr, As, Cd, Hg, Pb and Sr higher (WHO limit) than their respectively permissible levels. G.Murali, C.M.Vivek Vardhan [3] conducted an experimental study influence of addition of waste materials like lathe waste, soft drink bottle caps, empty waste tins, waste steel powder from workshop at a dosage of 1% of total weight of concrete as fibres. The lathe waste, empty tins, soft drink bottle caps were deformed into the rectangular strips of 3mm width and 10mm length. That concrete blocks incorporated with steel powder increased its compressive strength by 41.25% and tensile strength by 40.81%. Soft drink bottle caps reinforced blocks exhibited an increase in flexural strength of concrete by 25.88%. Better split tensile strength was achieved with the addition of the steel powder waste in concrete. The strength has increased upto 40.87% when compared to that of the conventional concrete specimen. Marcin Małek et al [4] studied the effect of adding steel chips without pre-cleaning on the properties of concrete.Steel waste was added as a replacement for fine aggregate in the amounts of 5%, 10% and 15% of the cement weight, which correspond with 1.1%, 2.2% and 3.3% mass of all ingredients and 0.33%, 0.66% and 0.99% volume of concrete mix, respectively. The slump cone, air content, pH value, density, compressive strength, tensile strength, tensile splitting strength, elastic modulus, Poisson's ratio and thermal parameters were tested. It was observed that with the addition of lathe waste, the density decreased, but mechanical properties increased. No effect was observed on thermal conductivity. Manpreet Kaur et al [5] deals with the assessment of the risk exposure related to heavy metal contents in groundwater and soil samples to two different age groups via three different transits, i.e., ingestion, inhalation and dermal. The concentrations of heavy metals (Zn, Cd, Cu, Pb and Cr) were measured in the villages of lower Himalayas of Reasi district by using microwave plasma atomic emission spectrometer. All the mean values of the concentration. of heavy metals in water and soil samples were found to be less than the values prescribed by various agencies. All the metal concentration in the soil samples were found to be low contaminated and the corresponding value of pollution load index calculated less than unity.

3. METHODOLOGY FOR DATA COLLECTION

Water samples were collected from different household wells near to Technocraft industrial estate at kulapully. Water sample was collected from 3 bore wells and 3 open wells . At a distance of 1 km within the area. 500 ml samples were collected in plastic bottles. Reuse of lathe waste is done by collecting of waste sediments and granules are added to concrete and tests are done. Based on the test results, it can be concluded that the metal chips released into the environment may cause pollution to the water sources and hence it can be utilized in concrete. Literature study was done on the available data on use of metal chips in concrete. Metal chips were collected from Lakshmi industries kulapully. Mix design for different proportions of concrete was decided and tests were performed to obtain the strength and properties of different mixes. Based on the literature survey and optimum quantities of bottle caps and steel powder, the combinations were adopted.

Fig -1: Effect on ceramics and steel fittings due to excess iron content and hardness in domestic water

3.1 Experiments conducted on water samples

The samples collected were stored in plastic bottles and following water quality tests were done in Environmental Engineering laboratory of Jyothi Engineering College, Cheruthuruthy, Thrissur. The tests done were pH, Total Dissolved Solids (TDS), Total hardness and Iron content, other tests conducted are COD, BOD turbidity, alkalinity, chloride, fluoride, nitrate, manganese, sulphate etc. The obtained results are compared with IS 10500 2012.

3.2 Utilisation of metal chips

Based on the test results, it can be concluded that the metal chips released into the environment may cause pollution to the water sources and hence it can be utilized in concrete. Literature study was done on the available data on use of metal chips in concrete. Metal chips were collected from Lakshmi industries kulapully. Mix design for different proportions of concrete was decided and tests were performed to obtain the strength and properties of different mixes.

3.3 Tests performed on raw materials used in concrete

The raw materials used in concrete mix are cement, coarse aggregate, fine aggregate and water in required proportions. The colour of cement should be uniformly greenish grey. And when hand is thrusted into a bag of cement it should feel cool. Crushed stones of size more than 4.76mm are known as coarse aggregate. Coarse aggregate of size upto 80mm are used in building and road construction. Specific gravity, void ratio, porosity calculation and sieve analysis were performed on coarse aggregate sample. Specific gravity of the taken sample of coarse aggregate is 3.06, void ratio 0.257% and porosity 0.44%. Maximum size of aggregates used in the test was 20 mm. M-sand is used as an alternative for river sand. Manufactured sand is an alternative for river sand. lathe waste of 10%of cement is used. The steel wastes are in shape of thin coiled fibers of size 3mm width and 5cm length.

3.4 Mix design calculations

M30 grade concrete was prepared by doing mix design calculations. The proportions of materials used is obtained after mix design procedure and are as follows:

Quantity of cement = 10.54kg

Fine aggregate = 23.3Kg

Coarse aggregate = 37.01Kg

Water = 4.98litre

The ratio of cement: coarse aggregate: fine aggregate is 1.00:2.26:3.30.

3.5 Experiments work on concrete cubes

The casting is done in cast ion cubes of standard dimension of 150mm×150mm×150mm from Material Testing Laboratory of Al Ameen Engineering College, Kulapully. The casted concrete cubes were cured in water tank, demoulded and slump test and compression test was done.

4. RESULTS AND DISCUSSIONS

Table -1: Water sample collected from Bore well

Sl. No	Parameter	Unit	Acceptable limit	Permissible limit	Observed value
1	Turbidity	NTU	1	5	2.4
2	pH	No unit	6.5-8.5	No relaxation	6.3
3	TDS	mg/l	500	2000	241
4	Alkalinity	mg/l	200	600	50
5	Total hardness	mg/l	200	600	525
6	Chloride	mg/l	250	1000	11.03
7	Fluoride	mg/l	1	1.5	Nil
8	Nitrate	mg/l	45	No relaxation	Nil
9	Iron	mg/l	0.3	No relaxation	0.91
10	Manganese	mg/l	0.1	0.3	Nil
11	Sulphate	mg/l	200	400	5.6
12	Sulphide	mg/l	0.05	No relaxation	Nil
13	COD	mg/l	-	-	Nil
14	BOD	mg/l	-	-	nil

Table -2: Water sample collected from open well

Sl. No	Parameter	Unit	Acceptable limit	Permissible limit	Observed value
1	Turbidity	NTU	1	5	1.5
2	pH	No unit	6.5-8.5	No relaxation	6.9
3	TDS	mg/l	500	2000	38
4	Alkalinity	mg/l	200	600	80
5	Total hardness	mg/l	200	600	320
6	Chloride	mg/l	250	1000	2.75
7	Fluoride	mg/l	1	1.5	Nil
8	Nitrate	mg/l	45	No relaxation	Nil
9	Iron	mg/l	0.3	No relaxation	0.82
10	Manganese	mg/l	0.1	0.3	Nil
11	Sulphate	mg/l	200	400	6
12	Sulphide	mg/l	0.05	No relaxation	Nil
13	COD	mg/l	-	-	Nil
14	BOD	mg/l	-	-	nil

- From (Table 1) in case of borewell, turbidity, total hardness and iron content are more than the acceptable limit.
- In case of open well (Table 2) total hardness and iron content shows a higher value as compared to the acceptable value.
- While comparing the two sources of water it can be concluded that water sample collected from borewell shows a higher variation in the values as compared to sample collected from open well.
- The yellow stains seen on wash basins and water closets are an evidence for the presence of dissolved solids and iron content in the water sample. Similarly the water mark that appears on vehicle glasses are also an evidence for the scenario.

After testing the compression strength the results were taken and compared with strength of normal concrete.

The results were taken after 7,14,28 days. The results are shown in table and its graphical representation.

Table -3: Compressive strength of concrete after 7 days

Concrete mix	Load(kN)	Strength(N/ mm²)
Conventional concrete (0%)	420	18.66
Replacement of aggregate with 5%	470	20.88
Replacement of aggregate with 8%	430	19.11
Replacement of aggregate with 10%	410	18.22

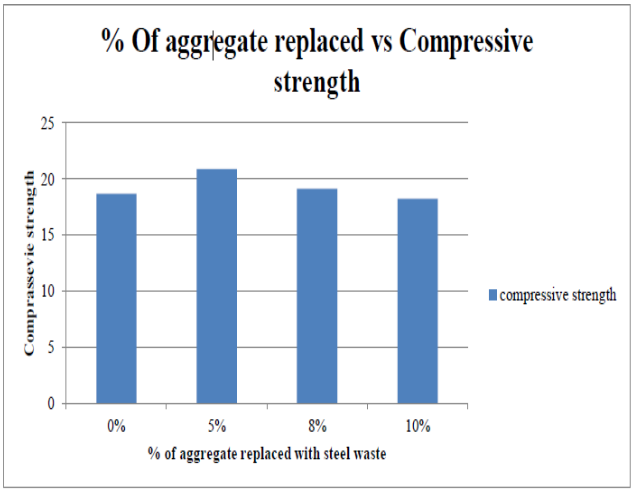

Chart -1: Graphical representation of Compressive strength after 7 days

Table -4: Compressive strength of concrete after 14 days

Concrete mix	Load(kN)	Strength(N/ mm²)
Conventional concrete(0%)	480	21.33
Replacement of aggregate 5%	560	24.88
Replacement of aggregate 8%	500	22.22
Replacement of aggregate 10%	490	21.77

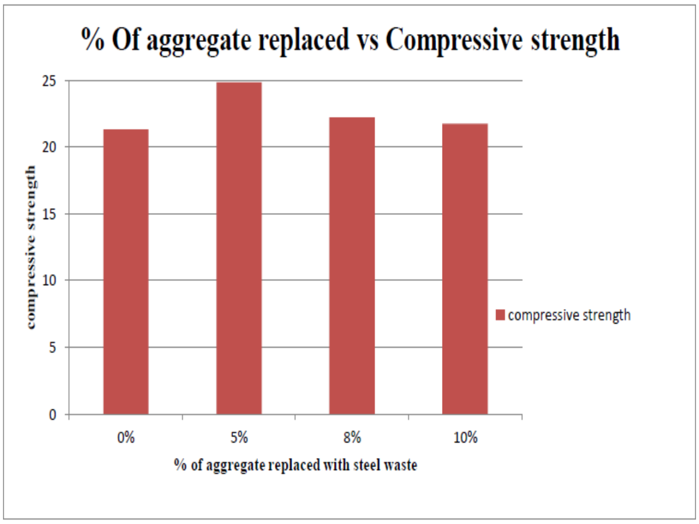

Chart -2: Graphical representation of Compressive strength after 14 days

Table -5: Compressive strength of concrete after 28 days

Concrete mix	Load(kN)	Strength(N/ mm²)
Conventional concrete (0%)	540	24.00
Replacement of aggregate with 5%	650	28.88
Replacement of aggregate with 8%	570	25.33
Replacement of aggregate with 10%	550	24.44

In case of borewell, turbidity, total hardness and iron content are more than the acceptable limit. The observed value of total hardness of the water sample collected from borewell is 525 mg/l whereas the acceptable limit is 200 mg/l. Similarly iron content of that sample is 0.91 mg/l which is more that the acceptable limit of 0.3 mg/l. Similarly the observed value of total hardness of the water sample collected from openwell is 300 mg/l whereas the acceptable limit is 200 mg/l. Similarly iron content of that sample is 0.8 mg/l which is more than the acceptable limit of 0.3 mg/l.

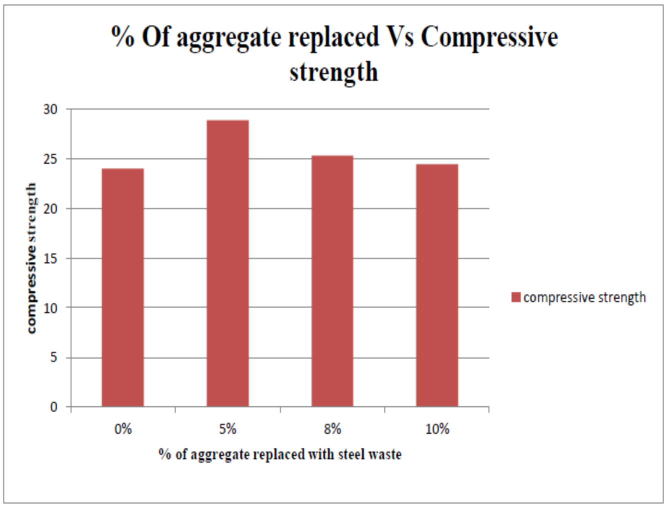

Chart -3: Graphical representation of Compressive strength after 28 days

So inorder to minimize the disposal of steel waste into open environment and there by its leachate to groundwater sources we can effectively use them as replacement for aggregate in concrete. Compressive strength was tested at 7 and 14 days by replacing aggregate with 5%, 8% and 10 % of steel waste. The 7 day and 14 day test shows 5% as optimum value as it gives higher value of compressive strength compared to 8% and 10%. 7 day compressive strength is maximum with 5% replacement of aggregate which is 20.88 N/mm^2. 14 day compressive strength is maximum with 5% replacement of aggregate which is 24.88 N/mm^2. 28 day compressive strength is maximum with 5% replacement of aggregate which is 28.88 N/mm^2.

5. CONCLUSIONS

On the basis of test data it can be inferred that the metal waste produced from the metal industries cause pollution to the water bodies and hence makes it unfit for drinking purpose. The excess iron content in the water gives bad taste to water and also creates marks and stains on ceramics, vehicle surface and tiles. The solution to overcome the effects of excess iron content and hardness of water is to install filters in houses. But it is an expensive method. So as an alternative, the metal chips can be used as replacement of aggregates or steel fibres in concrete. This project is an experimental study of using steel waste in concrete. M30 design mix is chosen . Metal chips are used as a replacement for coarse aggregate with varying percentages such as 0%, 5%, 8%, 10%. The workability and compression tests were carried out. From the obtained results it shows a very low workability. Compressive strength for 5% have more strength than other . 8% have strength more than conventional concrete but less than that of 5%. 10% have compressive strength near to conventional concrete. By using optimum percentage of Metal chips can improve the properties of concrete. Utilization of excessive amount of metal chips will reduce the strength of concrete.

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