International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.177
Volume 7 Issue V, May 2019- Available at www.ijraset.com

Sludge Management in Industries - A Perspective

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Abstract: ***Regular analyses for characterization of sludge samples from effluent/sewage treatment plants in a few industries viz. automobile / tractor unit, synthetic/man- made fibre unit, cotton textile unit, steel processing/cold rolling mill, hard board/ packing production unit, paper mill prompted this in House R & D unit to investigate into possibility of alternate and appropriate method of sludge management suitable for environmental setting of these industries.***
A few projects on sludge management from these units were assigned to students of M. Tech. (Env Engg.) from G.H. Raisoni College of Engg., Nagpur. Joint investigations have indicated more compatible sludge management system than the one being adapted at these industries e.g. i) phosphoric sludge by composting along with biological sludge from ETP at the automobile unit, ii) composting starch sludge from hard board packaging unit along with soil/cow dung, ii) pyrolysis of paint sludge in the automobile unit and probable recovery of organic chemicals like xylene, benzene etc. and iii) recovery of lignin from small scale paper mills using paddy husk/baggasse etc. for pulp production and use of recovered lignin for use as binder material.

I. INTRODUCTION

Enviro Techno Consult, Nagpur, a DST/DSIR recognized "In House R&D unit since 1993, has been associated with various industries in and around Nagpur. One of the reasons of this recognition is to help industries in their environment – related problems since each industry is unique and is required to be treated independently for its waste management. Enviro Techno Consult is also associated with G.H. Raisoni College of Engineering (Env. Engg.).

This college deputes two or three M. Tech. (Env. Engg.) students for one year for training and for dissertation on any environment-related subjects as a part of the curriculum. Hence, Enviro Techno Consult, has been able to depute these students on "real life" field problems related to projects in its scope of work. This practice has helped many students to get better jobs at the beginning of their service carriers.

Industries with which ETC has been associated in the recent past include i) automobile/tractor unit , ii) synthetic/man- made fibre unit, iii) cotton textile unit, iv) steel processing/cold rolling mill, v) hard board/ packing production unit, vi) paper mill etc. These industries have to operate under prevailing environment–related Environment Protection Act, Water Act, Air Act, Hazardous waste management rules.

Most industries generate wastewater, gaseous emissions, solid wastes etc. Effluent treatment plants (ETP) have been installed in the industries mentioned above. Majority of ETPs are based on aerobic biological techniques viz. activated sludge systems. Such systems invariably generate sludge (primary & or secondary) which is usually dried over sludge drying beds as a part of ETP design. ETP sludge has been legally categorized as "hazardous" and has to be disposed as per notification by MPCB[1]. Most industries have requested this laboratory to routinely analyze sludge samples from the effluent/sewage treatment plants. Presently, most industries transport the sludge to the common facility for disposal of "hazardous wastes". Commonly practiced method of sewage/biological sludge management is by its anaerobic digestion and to recover methane.

II. PURPOSE OF PAPER

An over view of industry-wise i) origin of sludge, ii) sludge characteristics has been collated in this paper. Predominant ingredient in each sludge type was identified. Other methods of sludge treatment depending on its characteristics which were tried in the laboratory and findings have been included in this paper. Present paper includes industry-wise average characteristics of sludge samples from automobile/tractor unit, synthetic/man- made fibre units, cotton textile units, steel processing/cold rolling mill, hard board/ packing production unit and paper mill. Valorization of sludge wherever possible has been indicated.

III. APPROACH

Industry-wise sludge samples have been classified Table 1which also includes its category as per its origin. Sludge samples were analyzed as per methods recommended in a publication entitled "Soil/ Solid waste analysis" by Anupama B.S., CPCB[2].

Table 1: Sludge category

S. No	Industry	Source of sludge	Category
1	Cotton mill	ETP	Biological
2	Synthetic fibre plant	ETP	Biological
3	Steel processing	Pickling, ETP	Inorganic/acidic Inorganic
4	Hard board/ packaging unit	de-inking starch/ packaging	Coloured, scum starchy
5	Paper mill waste paper as raw material	ETP	Biological /cellulosic
6	Fruit processing	ETP	Biological
7	Automobile	Paint shop Phosphoric ETP Sewage treatment plant	Synthetic/coloured pretreatment of parts to be painted Biological Biological

Table 2 includes industry -wise manufacturing processes generating waste water which is being treated in the respective ETP.

Table 2 : Processes in industries

Name of Industry	Processes involved
Cotton mill A	Cotton fibre processing - bleaching, spinning, weaving mercerizing, dyeing
Cotton mill B	Weaving, mercerizing, dyeing etc.
Synthetic fibre	PTA, polymerization and spinning.
Steel processing	Pickling of H.R. sheets in hydrochloric acid, washing, rolling, colour-coating, etc.
Packaging Unit	Conversion of paper into packing hard paper board sheets and printing.
Fruit processing unit	Freeze drying of fruits and packing of fruit powder.
Automobile	Assembly of vehicles, their washing, drying, phosphate treatment before painting.
Composite paper mill	Raw material is bagasse, bamboos, trees, paddy husk etc. These mills segregate cellulosic contents of for pulp for paper making by using strong alkalis during which lignin is dissolved and black liquor containing lignin is generated.

Table 3 includes the names of persons those who have characterized and worked on these samples.

Table 3 : Personnel involved in the study

Topic	Names
Cotton mills, synthetic fibre plant, steel processing, paper mill, fruit processing	Staff at Enviro Techno Consult
Paint shop sludge	Miss Nutan Gadhekar*
Phosphoric sludge	Miss Kajal Ghanade*
Hard board/ packaging unit Deinking Starch waste	 Mr. C. Hardas* Mr. Kadwe*
Sewage treatment plant	Miss Jayashri Bhelawe* & Enviro Techno Consult

*M. Tech. (Env.) students during 2016-19

IV. FINDINGS AND RESULTS

Averages of chemical characteristics of sludge samples from individual industries are given in **Table 4** along with standard deviations wherever sufficient number of analyses were available.

Table 3: Averages & standard deviation of industry-wise sludge quality

Parameter	Cotton mill		Synthetic fibre	Steel processing	Hard board Packaging unit		Fruit processing	Automobile			
	Mill A **(31)**	Mill B **(8)**	**(22)**	**(29)**	Ink **(4)**	Glue **(4)**	**(10)**	Paint **(14)**	Phosphoric **(4)**	ETP **(19)**	STP **(37)**
pH	6.2-8.8	6.2-8.0	6.4 - 7.7	6.4 -12.8	6.2	5.4	6.8-8.1		7.4	5.5-7.6	
Moisture %	61.8±25.9	67.2±24.8	71.7±21.7	35.4±10	51	23	86.8±3.6	51.7±17	81.8	24.9±18.3	25.9±5.5
B.D. g/cc	0.8±0.3	0.78±0.1	0.75±0.1	0.93±0.1	1.0	1.3	1.2±0.4	0.78±0.2	0.9	0.5±0.2	0.4±0.3
Volatile matter,%	29.9±16	50.5±6.3	71.1±13.6	33.6±14	89.0	98.8	69.1±15.2	76.3±6.2	50.6	60.6±8.0	63.4±1.8
Ash%	71.4±17	20.1±7.79	28.5±13.4	-	49	77	30.8±15.2	24.24±7.5	49.4	38.9±8.3	39.8±8.7
Chloride, mg/kg	1444±1929	1569±1291	222.5±137	43305`±2810	70	189	798±551	N.D.	300	1860±1730	390±172
Sulphate mg/cc	1060±1218	2071±2283	277±250	528±224	119	58	440±244	N.D.	600	448.4±208	527±120
T nitrogen, mg/kg	9.5±5.3	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D	830	N.D	3.2±1.3
T.phosphate mg/kg	58.2±63	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D	260	N.D	2.3±0.6

N.B. i) Number in parenthesis contains is of samples analysed; ii) Heavy metals (Cr, Cd, Cu, Pb, Ni, Zn) were estimated in steel processing, paint sludge, phosphoric sludge and ,ETP for the automobile plant.

V. DISCUSSION

Main sources of sludge were effluent treatment plants (ETP) and sewage treatment plants (STP) in the industries under study viz. synthetic/ man- made fibre units, cotton textile units, steel processing/cold rolling mill, hard board/ packing production unit and paper mill. But, in the automobile industry sludge is also generated during manufacturing processes e.g. i) phosphoric sludge is generated during treatment of parts to be painted, ii) paint sludge is generated in paint booths in the washed water. Present sludge management systems, in vogue in these industries are included in Table 4.

Table 4 : Present sludge management in industries:

Industry & type of sludge	Predominant parameter/s in sludge	Disposal practice in vogue
Textile –cotton & synthetic fibre	Moisture & organic matter	Land disposal
Steel processing	Chloride	Stored in premises
Hard board/ packaging	Organic matter	Land disposal
Fruit processing	Moisture & organic matter	Land disposal
Sewage treatment plants	Moisture & organic matter	Land disposal
Automobile unit Paint sludge Phosphoric	Volatile matter, moisture Phosphate, nitrogen, organic matter	Transport of phosphoric and paint sludge to common hazardous waste treatment facility near Nagpur.

Laboratory scale experiments were jointly conducted by the students cited earlier and the staff of Enviro Techno Consult on i) paint sludge, ii) phosphoric sludge and iii) the starch-rich sludge from hard board packaging unit. **Table 5** includes an abstract of what was experimented with a few sludge samples in the laboratory and of observations on findings. Details of experiments are available [2-5].

Table 5 : Abstract of laboratory experiments & findings

Sludge type	Experiment conducted	Reason	Findings
Phosphoric sludge	Aerobic composting by windrows with cow dung	i) To enrich normal compost with N,P,K ii) Co-disposal of partially dewatered/ sun dried ETP/STP sludge on.	i) There was rise in temperature of wind row showing microbial activity. ii) Microbial mineralization of sludge indicated by increase in soluble phosphate in compost
Paint sludge	Feasibility of pyrolysis	i. Literature survey ii. Problem in storage iii. Transportation cost	i)Calorific Value- 5705 kcal/Kg -Soluble in liquid waste from paint shop called Thinner waste. -Flash point /Pyrolysis temp. 450-650°C -Pyrolysis duration 60-90 min. - recovery of xylene/benzene possible & - byproduct char will be industrial adsorbent
Starchy sludge Packaging unit	Aerobic composting by windrows with cow dung	i. Starch is easily degradable ii. Space available iii. Market for manure available	Sludge is easily compostable by conventional wind row method and weekly turning. Specific microbial cultures are commercially available.
Black liquor from composite paper mill	pH reduced < 3 Lignin settles. Sulphonate lignin with Cr salt as catalyst under pressure	i. Lignin is not biodegradable & imparts colour to ETP treated wastewater. ii. Lignin causes froth during aeration in activated sludge system.	Product of sulphonation of lignin is "lingo-sulphonate" which is a good commercial dust suppressant .
Steel industry sludge	Land fill material in abandoned stone quarry	Sludge predominantly included partially dried ferric hydroxide	Stone quarry bottom is impervious since rain water is stored till the months of November /December.

VI. CONCLUSIONS

Following conclusions can be drawn on basis a) studies conducted and b) characteristics of sludge samples and in the interest of industry.

A. Phosphoric Sludge From Automobile Unit

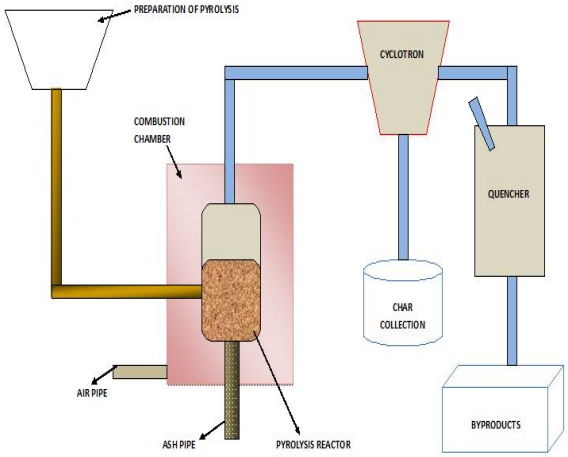
1) It should be sundried over the existing filter beds at STP/ETP.
2) Mixed sludge can be composted in windrows of $1m^3$ capacity each, height being 0.5 m.
3) Windrows to be turned over every 10^{th} day & treated effluent to be used to maintain moisture

B. Packaging Unit Starch Sludge

1) Regular sludge removal from the pit, mix with soil/cow dung and lay windrows for composting
2) Turn windrow every 7^{th} day

C. Paint Sludge

Pyrolysis of sludge is feasible. A pilot pyrolysis unit with following configuration can be considered which will help in assessment of quantities of i) recovered chemical, ii) by product char, iii) method of heating micro wave or conventional and iv) optimization of pyrolysis process –duration and temperature



D. Lignin Problem In Small Scale Paper Mills

Small paper mills produce pulp out of paddy husk, bagasse and other cellulosic material. They do not separate lignin. They hold wastewater in lagoons which are emptied in rainy seasons. Pilot scale studies mentioned below can be useful. They can acidify a part of their wastewater to remove lignin at pH less than 4.0 allow the acid treated wastewater to settle in properly designed tanks. Precipitated lignin can be dried. It can contain chemicals like sweet -smelling vanillin. It can be used for manufacture of lingo-sulphonate or as binding material for scented sticks.

E. Steel Industry Sludge

Steel industry sludge if used for restoring the mine pit would not allow leachate to percolate. EIA of for small back filling project at Hingna industrial area an experimental has been carried out without any adverse impact.

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