PRESENCE OF HEAVY METALS IN SLUDGE GENERATED IN THE FACTORY OF

M/S HINDUSTAN COCA-COLA BEVERAGES PVT LTD., PALAKKAD

A STUDY REPORT

KERALA STATE POLLUTION CONTROL BOARD

September, 2003

1. Background

The factory of M/s Hindustan Coca-Cola Beverages Private Limited located at Plachimada in Palakkad district is engaged in the production of soft drinks since 2000. The products include Coca-Cola, Limca, Thums Up, Sprite, Kinley soda and Maaza. The factory is located in a plot of 38 acres. During the month of July a prominent British Journalist and anchor of BBC Radio 4's "Face the Facts" programme, John Waite visited this plant of M/s Hindustan Coca-Cola beverages Pvt. Ltd. On coming to know that the sludge from this plant was being used as manure in the nearby farming fields, he collected samples of this waste and water from nearby wells and analysed it at the laboratory operated by the University of Exeter in London. The results were announced through a pres release. It was alleged that the company is distributing highly toxic sludge containing cadmium and lead to the farmers as manure. The analysis of the samples in this laboratory detected the presence of significantly higher than normal levels of certain heavy metals such as lead, cadmium and chromium. The findings of this BBC report raised a lot of hue and cry in the state and hence the State Pollution Control Board decided to conduct its own study to find out the truth. The Government of Kerala directed the Member Secretary of the Board to conduct a detailed study and submit a report in this regard.

2. Objectives of the study

1. To study the operational process in the factory to detect presence of heavy metals during production
2. to study the quality of raw water, which is their raw material.
3. to study the treatment of process effluent and disposal of sludge generated.
4. to study the soil in the nearby area where sludge is applied as manure.
5. to study whether the waste generated in the company contains higher level of heavy metals such as lead cadmium, chromium, iron etc as reported by BBC
6. to study whether the sludge is hazardous in nature and how this has to be disposed off without causing any damage to the environment.
7. to study whether the water in the wells located adjacent to the company compound contains heavy metals in such concentration which makes water unfit for drinking purposes and if so suggest remedial measures to make the water fit for drinking.

3. Limitations of the study.

This report does not take into consideration other allegations such as depletion of ground water and contamination of the soft drink due to pesticides as these matters do not come under the purview of the Board.

4. Methodology

The study was conducted by proper inspection and collection of effluent, water, sludge and soil samples duly complying with the guidelines of the Central Pollution Control Board.

The analysis of the samples, collected during inspections were done at the Board's Central Laboratory at Kochi. The method adopted for analysis of samples is as referred in the Standard methods for examination of water and waste water (APHA AWWA WEF)-20th edition and is as follows

a) Processing of sample
Take 1.0g of oven dried (105ºC) thoroughly ground sample in a 250 ml conical flask. Add 10 ml of nitric acid, perchloric acid mixture acid mixture (10 parts of conc. Nitric acid, 4 parts of perchloric acid). Place a funnel over the flask. Evaporate gently on a hot plate until dense white fumes of perchloric acid appear. If solution is not clear keep solution just boiling until it clears. Cool. Wash down sides of the flask and funnel and dilute to approximately 50 ml with water. Filter the sample through whatman no. 42 filter paper and make up the filtrate to 100 ml in a volumetric flask.

Run a blank following the same procedure.

b) Measurement
Estimate the metal concentrations using Atomic Absorption Spectrophotometer as per the procedure given for the instrument applying blank correction. Report the result on dry weight basis in mg/kg.

Instrument minimum detection limit (Direct aspiration AAS)

Name of element		Conc. In mg/l
1.	Cadmium	0.002
2.	Chromium	0.02
3.	Copper	0.01
4.	Iron	0.02
5.	Manganese	0.01
6.	Nickel	0.02
7.	Lead	0.05
8.	Zinc	0.005

5. Compliance with legal requirement

The daily requirement of water in this unit on full production is about 15,00,000 litres. It is pumped from the six tube wells and two open wells within the factory premises. The maximum quantity of effluent generated during production is 8,00,000 litres per day. The Board has issued consent to operate under the Water (Prevention and Control of Pollution) Act and Air (Prevention and Control of Pollution) Act to the Company. The company has also obtained authorisation under the Hazardous Waste (Management and Handling) Rules 1989 for the disposal of waste oil generated.

6. Brief process description:

Raw materials: The raw materials include water, soft drink concentrate, carbon dioxide, sugar, mango pulp, preservatives, water treatment chemicals etc.

Treatment of raw water:

Water is drawn from the tube wells situated within the factory premise through sealed pipelines into the storage tanks in secured water treatment areas of the manufacturing plant. As a first step this water is subjected to chlorination to ensure destruction of microorganisms including pathogens, and oxidation of heavy metal ions and organic impurities. The chlorinated water is then subjected to sand filtration and is stored in storage tanks. This is sent to clarifier where lime, soda ash and $FeSO_4$ are also added. Contaminants commonly recovered at this juncture includes dirt, clay and other suspended matter, turbidity, undesirable organic matter, microbial matter and heavy metals and other compounds. Further reduction of pollutants is achieved by multi layers filtration, where suspended micro particles are removed. As an additional step, water is further cleaned using granular activated carbon purifier. Here using the principle of adsorption, trace levels of organic compounds, off-taste and odour causing compounds are effectively removed. To further ensure safety in the usage of water as beverage, the water is subjected to micron filtration by passing through 1-micron filter. The waste generated during the process is collected in sludge form. Flow chart of the process is annexed as annexure 1.

Production process

The production process is rather simple. High-grade sugar procured from sugar mill is subjected to Hot carbon treatment for removing impurities present in sugar and is then used for preparation of purified sugar syrup. The sugar syrup is then blended with the company's soft drink concentrate (different for different brand names) are then blended to form final product. The soft drink concentrate is manufactured in Pune district of India and supplied to all other beverage units of M/s Hindustan Coca Cola Beverages Pvt. Ltd.

Bottle washing and packing:

The glass bottles returned from the market are thoroughly cleaned and sanitized using cleaning agents at high temperature using sophisticated bottlewashers of bottle rinsers (in case of PET bottles). These bottles are then transported to the filter area using fully automated conveyor system. Beverage is then filled into glass containers or PET bottles using high speed automated filling machine.

Generation of solid and liquid waste:

Solid and liquid wastes are generated during the above mentioned production process employed in the factory. The solid waste generated during the raw water treatment is a light coloured sludge, which the firm had initially transported through outside parties to nearby farmers as manure. In addition to this sludge, the sludge generated from the effluent treatment plant, which is dark coloured was also transported to farmers for use as manure. The liquid waste generated during the process is directed to the effluent treatment plant.

Effluent treatment:

The raw effluent coming from the production process is directed through bar screens for removal of large objects and then passed through a chamber for removal of oil and grease. This effluent is then collected in a collection pit. HCL dosing is carried out during the passage of effluent to the equalisation tank. The effluent is then passed through tank where fixed bio film screens are used for removal of organic matter. The effluent coming out of this process passes through aeration tank and is then subject to a dual media filter. The treated effluent partially goes for gardening of the premises and the rest goes for crate washing, floor cleaning and to toilets and fire tanks. Flow chart of the effluent treatment is annexed as annexure 2.

7. Action taken by Board so far

M/s Hindustan Coca-Cola beverages Private Ltd. applied for consent of the Board in June 1999 to establish a factory in a 31 acre plot at Plachimada in Palakkad district for manufacture of 5,61,000 litres of soft drinks (Coca Cola, Limca, Fanta, Thums Up, Sprite, Kinley soda and Maaza) per day. As the company had proposed sufficient facilities for the treatment of waste water and emission gases, consent to establish was issued on 21.7.99. After the company installed the said facilities consent to operate the industry under the provisions of the Water Act was issued on 19-2-2000. These consents are issued subject to various conditions.

The Government of India in the Environment Protection Rules notified vide G.S.R 93(E) dated 21-2-91 prescribed the tolerance limits for waste water from soft drink plants as given below:

Sl. No.	Parameters	Unit	Tolerance limit
1.	pH		6.5-8.5
2.	Suspended solids	mg/l max	100
3.	Biochemical oxygen demand	mg/l max	30
4.	Oil and grease	mg/l max	10

Heavy metal like cadmium and lead are not anticipated in waste water from soft drinks factory and hence are not included in the aforesaid stipulation under the Environment Rules. Therefore no limiting standard for heavy metal is included by the Board in the consent. The sampling so far conducted by the Board shows the industry is complying with the tolerance limits specified by the Board.

The industry is having sufficiently tall stacks and the emissions from these conform to the tolerance limits for particulate matter (1200 mg/Nm3) and sulphur dioxide (1200 mg/Nm3).

Schedule 1 of the amended Hazardous Waste Rules list out 36 processes which require authorisation from the Board for storage, utilization and disposal of solid waste. Soft drink manufacture is not mentioned in the list and hence the industry was not required to take authorisation for disposal of the solid waste. They have however taken authorisation for disposal of waste oil and are complying with the conditions of the authorisation.

Many complaints were received in the past against the industry. The main allegation was that the extraction of water by the industry from bore wells and open wells is causing depletion of the ground water and hence depriving those nearby of their traditional water resource. The matter of ground water depletion comes under the Ground Water Department. Even then the Board collected samples from the wells reportedly affected and conducted analysis. The results indicated that these wells were not contaminated due to the disposal of effluent. But slightly higher concentration of chlorides could be detected.

On coming to know from the media about the BBC report on high concentration of cadmium and lead in the sludge from the industry and in nearby wells, the officers of District Office of the Board at Palakkad collected random samples of sludge and effluent and those were analysed in the Board's Laboratory at Eranakulam. The result indicated a cadmium concentration of 201.8 mg/kg in the sludge.

8. Inspections and sampling

Normal routine inspections are carried out from the District Office of the Kerala State Pollution Control Board at Palakkad.

The present set of inspections were conducted under the leadership of the Member Secretary. The inspections were conducted on 5.8.2003, 28.8.2003 and 29.8.2003. The samples of sludge heaped outside the factory premises, samples of soil, well water used in the production, raw and treated effluent, water in the wells of surrounding area etc were collected for analysis.

8.1 Inspection on 5.8.2003

During this inspection the Member Secretary and his team comprising Sri. A.B Pradeep Kumar, Environmental Engineer, Head Office and Smt.C.V Jayasree, Environmental Engineer, District office, Palakkad were accompanied by the President, Secretary and members of the Perumatty Grama Panchayat and a representative of the agitating public. As the President was keen to know about the harmful effects of the sludge used as manure in some nearby areas, inspection and sampling were carried out in such premises where the sludge was used as manure.

8.1.a Premises of Sri Manikyam Chettiar

Sri Manikyam Chettiar is one of the farmers who had used the sludge as manure in his coconut field. The area comes in Kozhiyampara Panchayat, Mannamala P.O behind the factory of M/s Bhagavathy Textiles.

Sludge from the factory of M/s Hindustan Coca Cola Beverages Private Ltd was seen disposed in this site. The dark coloured sludge from the Effluent Treatment Plant was seen in dry form heaped together in the premises (SS_2). The light coloured sludge from the water treatment plant was seen stacked in plastic bags (SS_1). A combination sample was taken from this soil also (SS_3). The top soil of the surrounding area where there is no land application of sludge was also collected (SS_4). Thus a total of four samples were collected from this plot.

8.1.b Premises of Sri. Chenthamara

Shri. Chenthamara is residing in Manalthodu in Kozhiyampara Panchayat and sludge from the company was seen dumped in this site also. The sludge similar to the type found in Manikyam Chettiar's site was seen in this site also. Sand like sludge in plastic bags (SS_5) which seemed to be the dirty filter media, sludge in semi fluid form indicating recent arrival from company premises (SS_6 and SS_7) were taken. Some liquid substance resting on top of sludge sample in the nearby pond (SW_8) was also collected for analysis.

8.1.c Factory premises

The factory and its surroundings are maintained in a very clean and hygienic manner. Utmost care is taken to see that there is no spillage or littering within the premises. Proper landscaping and gardening is seen done. A part of the treated effluent is used for gardening purpose. Proper and scientific measures are seen adopted for rainwater harvesting.

The raw water pumped from the bore wells and open wells are stored in collection tanks and a sample of this water was collected (RW_9). Raw water was also collected from the storage pond outside the factory (RW_{10}). The light coloured sludge which is released after water treatment was seen stored in a concrete tank after packing in plastic bags. It is from here that these bags were transported to outside agencies for use as manure. Sample of this sludge was collected (SS_{11}). Dark coloured sludge lying in company's compound on a corner from where it was transported for use as manure was also collected (SS_{12}). Sample was also collected from the sludge drying bed of the ETP (SS_{13}). Raw effluent before entering the ETP (RE_{14}) and treated (TE_{15}) from clarifier tank before going for filtering were also collected.

8.2 Inspection on 28.8.2003

On 28.8.03, the same team led by the Member Secretary inspected the surrounding areas of the factory. The wells close to the factory on the western and eastern side were sampled. On the eastern side four numbers of well water samples viz. CEW_1 from Sri Pazhavathol's well in his plot, CEW_2 well water from the plot of Sri Subramanian of Vijayanagaram colony, CEW_3 the common Panchayat well, CEW_4 well water from bore well situated just outside the company compound were taken for analysis. The residents in this area complained about the quality of these well waters. None of them had used the sludge as manure and hence they had no complaints.

On the western side, one sample each from the bore well of Plachimada colony (CWW_1) and an open well of Sri Arusami Gounter (CWW_2) presently being used only for agricultural purposes were collected.

The team once again visited the site of Sri Manikyam Chettiar who had used the sludge as manure previously and it was found that all the sludge previously stored in the compound during the inspection on 5-8-03 had been removed as directed by the Board. However this time a well water sample (WW_1) and soil sample in the land where this manure was applied previously (AS_1) were collected.

8.3 Inspection on 29-8-2003

On 29th the factory was inspected again. Raw water from the storage tank after chlorination (CRW) and before chlorination (CPRW) were collected. Treated raw water before going for production was also collected (TRW). From the effluent treatment plant raw effluent (CRE), treated effluent after clarifier and before passing through filter (CCTE) and sludge from ETP (CES_2) and carbon sludge (CCS_1) were collected for analysis.

9. Cadmium

Since Cadmium was the heavy metal detected to be above the permissible limits by the BBC team and also by the Board in its sampling, a brief literature on Cadmium is included as follows:

9.1 Levels of Cadmium in the Environment

Cadmium emissions arise from two major source categories, natural sources and man-made or anthropogenic sources. Emissions occur to the three major compartments of the environment – air, water and soil, but there may be considerable transfer between the three compartments after initial deposition. Emissions to air are considered more mobile than those to water which in turn are considered more mobile than those to soils.

9.2 Natural Cadmium Emissions

Even though the average cadmium concentration in the earth's crust is generally placed between 0.1 and 0.5 ppm, much higher levels may accumulate in sedimentary rocks, and marine phosphates and phosphorites have been reported to contain levels as high as 500 ppm (Cook and Morrow 1995, WHO 1992).

9.3 Cadmium in Air

Three distinct categories may be recognised with respect to cadmium in air concentrations – cadmium in ambient air, cadmium air levels in occupational exposure situations, cadmium in air from the smoking of tobacco. Cadmium in ambient air represents, by far, the majority of total air borne cadmium. Inputs from all three categories may affect human cadmium intake and human health, but the levels and the transfer mechanism to humans are substantially different for the three. Whereas cadmium from occupational environments and cadmium from cigarette smoke are transferred directly to humans. Cadmium in ambient air is generally deposited onto water or soil, then eventually transferred to plants and animals and finally enters the human body through the food chain. Ambient air cadmium concentrations have generally been estimated to range from 0.1 to 5 ng/m^3 in rural areas from 2 to 15 ng/m^3 in urban areas (Elinder 1985, WHO 1992, OECD 1994) although some much lower values have been noted in extremely remote areas and some much higher values have been recorded in the past near uncontrolled industrial sources.

9.4 Cadmium in water

The average cadmium content in the world's oceans has been reported as low as <5 ng/L (WHO 1992) and 5.20 ng/L (OECD 1994, Jensen and Bro-Rasmussen 1992) as high as 110 ng/L (CRC 1996). 1.00 ng/L (Cook and Morrow 1996) and 10 to 100 ng/L (Elinder 1985). Higher levels have been noted around certain coastal areas (Elinder 1985) and variations of cadmium concentration with the ocean depth presumably due to patterns of nutrient concentrations, have also been measured (WHO 1992, OECD 1994). Even greater variations are quoted for the cadmium contents of rainwater, fresh waters, and surface waters in urban and industrialised areas. Levels from 10 ng/L to 4000 ng/L have been quoted in the literature depending on specific location and whether or not total cadmium or dissolved cadmium is measured (Elinder 1985, WHO 1992, OECD 1994).

9.5 Cadmium in Soil

Cadmium in soils is derived from both natural and anthropogenic sources. Natural sources include underlying bedrock or transported parent material such as glacial till and alluvium. Anthropogenic input of cadmium to soils occurs by aerial deposition and sewage sludge, manure and phosphate fertiliser application. Cadmium is much less mobile in soils than in air and water. The major factors governing cadmium speciation adsorption and distribution in soils are pH, soluble organic matter content hydrous metal oxide content, clay content and type, presence of organic and inorganic ligants, and competition from other metal ions (OECD 1994). The use of cadmium containing fertilisers and sewage sludge is most often quoted as the primary reason for the increase in the cadmium content of soils over the last 20 to 30 years in Europe (Jensen and Bro-Rasmussen 1992).

The average natural abundance of cadmium in the earth's crust has most often been reported from 0.1 to 0.5 ppm, but much higher and much lower values have also been cited depending on a large number of factors. Igneous and metamorphic rocks tend to show lower values, from 0.02 to 0.2 ppm whereas sedimentary rocks have much higher values from 0.1 to 25 ppm. Naturally zinc, lead and copper ores which are mainly sulphides and oxides contain even higher levels 200 to 14,000 ppm for zinc ores and around 500 ppm for typical lead and copper pores. The raw materials for iron and steel production contain approximately 0.1 to 5.0 ppm while those for cement production contain about 2 ppm. Fossil fuels contain 0.5 to 1.5 ppm cadmium, but phosphate fertilisers contain from 10 to 200 ppm cadmium (Cook and Morrow 1995).

Numerous agencies have upon the presence of cadmium in agricultural soils, the means by which agricultural soils may be enriched by cadmium, the degree to which cadmium is taken up by food stuffs and the subsequent transfer of cadmium to humans via food stuffs. Because cadmium is a naturally occurring component of all soils, all food stuffs will contain some cadmium and therefore all humans are exposed to natural levels of cadmium. Although much attention has been focused upon cadmium content of agricultural soils, it is important to recognise that the cadmium content of food items varies more as a function of the nature of the crop grown and the agricultural practices followed. Except in cases of extreme contamination, the concentration of cadmium in soils is not primary determinant of cadmium in the human diet. For example, leafy vegetables and potato tubers naturally accumulate higher levels of cadmium than do fruits and cereals (Menon et al 1998). Moreover tillage and crop rotation practices similarly have a greater impact upon the cadmium content of food than does the concentration of cadmium in soils (Menon et al 1998).

9.6 Cadmium exposure and human health

It has been well established that excess cadmium exposure produces adverse health effects on human beings. For virtually all chemicals, adverse health effects are noted at sufficiently high total exposures. For certain elements such as copper and zinc which are essential to human life, a deficiency as well as an excess can cause adverse health effects. Cadmium is not regarded as essential to human life. The relevant questions with regard top cadmium exposure are the total exposure levels and the principal factors which determine the levels of cadmium exposure and the adsorption rate of the ingested/inhaled cadmium by the individual, in other words, the pathways by which cadmium enters the food chain, the principal pathway of cadmium exposure for most human beings.

The kidney is the critical target organ for the general population as well as for occupationally exposed populations. Cadmium is known to accumulate in the human kidney for a relatively long time from 20 to 30 years, and, at high doses, is also known to produce health effects on the respiratory system and has been associated with bone disease. Most of the available epidemiological information on cadmium has been obtained from occupationally exposed workers in highly contaminated areas.

Most studies have centred on the detection of early signs of kidney dysfunction and lung impairment in the occupational setting, and, in Japan, on the detection and screening for bone disease in general populations exposed to cadmium-contaminated rice. More recently, the possible role of cadmium in human carcinogenesis has also been studied in some detail.

For chronic cadmium exposure, effects occur mainly on the kidneys, lungs and bones. A relationship has been established between cadmium exposure and proteinuria (an increase in the presence of low molecular weight proteins in the urine and an indication of kidney dysfunction) (WHO 1992, OECD 1994). Cadmium is known to accumulate in the renal cortex, and there is evidence that the level of cadmium in the renal cortex associated with increased urinary excretion is about 200 to 250 µg/g (wet weight).

Most human cadmium exposure comes from ingestion of food and most of that arises from the uptake of cadmium by plants from fertilisers, sewage sludge manure and atmospheric deposition, specifically the model estimated that the relative importance of various cadmium sources to human exposure is as follows (Van Assche 1998).

Phosphate Fertilisers	41.3%

Fossil Fuel Combustion	22.0%
Iron & Steel Production	16.7%
Natural Sources	8.0%
Non-ferrous Metals	6.3%
Cement Production	2.5%
Cadmium Products	2.5%
Incineration	1.0%

Clearly, of the anthropogenic sources of cadmium, phosphate fertilisers, fossil fuel combustion and some industrial activities contribute far more to human cadmium exposure than production, use and disposal of cadmium products and incineration of all cadmium-containing materials.

10. Results and discussion

The analysis report of samples collected during the first inspection conducted on 5.8.2003 and the results of the subsequent inspections conducted on 18th & 29th August is presented and discussed in this chapter. The parameters monitored include Cadmium, Chromium, Lead, Copper, Iron, Manganese, Nickel, Phosphates, Zinc and Arsenic along with pH. All sludge and soil samples are slightly alkaline in nature.

Samples collected from each premise is discussed separately.

10.1 Premises of Sri. Manikyam Chettiar

SS_1, SS_2, SS_3 & SS_4 are all samples from the same plot. SS_1 & SS_2 being two types of sludge used as manure in that area. SS_3 being the sample of soil in the land where these manure were applied and SS_4 the soil sample in the area, where application of manure has not been done. All these samples were collected during inspection on 5-08-03. The well water samples WW_1 was collected during inspection on 28-8-03 and another soil sample AS_1 was also collected on 28-8-03. As the controversial parameter is cadmium, importance is given to this parameter while discussing. The summary of the analysis report of the samples collected from the premises of Sri Manikyam Chettiar is given in table 1.

Table –1 Analysis report of samples from Sri Manikyam Chettiar's premises

Sl.No	**Description**	**Code**	**Concentration in mg/kg**									
			Cd	Cr	Cu	Fe	Pb	Mn	Ni	P	Zn	As
1.	Light coloured sludge	SS_1	5	9.1	11.4	818	65	63.4	37.7	2.0	49	BDL
2.	Dark coloured sludge	SS_2	2.5	BDL	26.1	636	52	198.4	7.3	BDL	204	BDL
3.	Manure applied soil sample	SS_3	20.8	3.11	23.2	390	55	144	28.5	0.3	95	BDL

4.	Plain soil sample	SS_4	3.9	54.1	7.0	1200	61	179.7	27.2	4.0	41	BDL
5.	Manure applied soil sample-2	AS_1	0.5	70.4	23.6	1220	18	8	6.5	BDL	46.3	BDL

BDL - Below detectable limits

Cadmium level is highest (20.8 mg/kg) in the sample SS_3 i.e. in the soil where the manure had been applied. Surprisingly both the sludge samples show low concentration of cadmium 5 mg/kg and 2.5 mg/kg respectively.

Cadmium to an extent of 3.9 mg/kg is present in the natural soil reported to be not applied with the sludge. The higher concentration of Cadmium in the applies soil maybe due to the continuous application of sludge for the last few years. On the day of the first visit instructions were given to Sri. Manikyam Chettiar not to apply sludge any further in his field. The samples collected from the same site on 28-8-03 shows that the presence of Cadmium in the applied soil has come down to as low as 0.5 mg/kg on stopping the application of sludge.

Concentration of lead in all samples is almost the same and is below the limit of 5000 mg/kg to classify it hazardous waste. The concentrations are 65 mg/kg and 52 mg/kg in the respective sludge samples and 55 mg/kg in the applied soil. Interestingly slightly higher level of 61 mg/kg in soil during the second inspection i.e. after stopping the application of sludge.

Concentration of chromium is also very low when compared with the standard of 5000 mg/kg for categorising as hazardous waste. It is just 9.1 mg/kg in first sludge sample and in the other one it is below detectable levels. Concentration (54.6 mg/kg) of chromium is seen in the natural soil (SS_4) reportedly not applied with the sludge and hence this needs further examination. The sludge might have been applied in this area also. Also the rains in between could have altered the situation. The study of the soil in that area is continuing to ascertain the cause of heavy metal in the natural soil and the effect on the sludge applied areas.

10.2 Premises of Sri. Chenthamara

The samples collected from this compound include SS_5, $SS_{6,}$ $SS_{7,}$ & $SW_{8.}$ The summary of the results are given in Table-2.

Table-2 Analysis report of samples from Chenthamara's premises

Sl.No	Description	Code	Concentration in mg/kg									
			Cd	Cr	Cu	Fe	Pb	Mn	Ni	P	Zn	As
1.	Sludge in plastic bags	SS_5	1.5	BDL	49.6	1000	31	144	31.5	6.0	225	BDL

2.	Dark coloured sludge	SS_6	18.4	134	54.4	600	266	39.2	12.9	3.0	301	BDL
3.	Dark coloured sludge-2	SS_7	16.4	50.9	104.7	1072	288	115.3	21.6	40	342	BDL
4.	Semi-fluid sludge	SW_8	BDL	BDL	BDL	1.36	BDL	BDL	BDL	8.0	BDL	BDL

Here again in the case of sludge samples, i.e. in first 3 samples presence of cadmium is negligible and is only 1.5 mg/kg, 8.4 mg/kg and 16.4 mg/kg respectively. However higher values of lead concentration is seen in samples SS_6 & SS_6 the values being 266 mg/kg and 266 mg/kg respectively. This value too is very low when compared with the limit the limit of 5000 mg/kg to consider this sludge as a hazardous waste. The liquid material collected from the top sludge SW_8 does not show relevant presence of any heavy metal. This indicates that the soluble component of heavy metal in the sludge is too low and the impact of sludge on ground water will be negligible. However a detailed leachability study is required to establish this finding.

10.3 Factory premises

The summary of analysis of raw water and treated water is given in table 3.

The raw water stored in collection tanks was samples as sample RW_9. The pH of this water is 7.1 and the only heavy metal detected is Nickel which is just 0.14 mg/l. The raw water stored in storage pond outside the factory building RW_{10} is of pH 6.9 and there is no trace of any heavy metal. Hardness of 840 mg/l and 970 mg/l is seen in the raw water samples CRW and CPRW. Hardness has been reduced in the treated water TRW but negligible quantities of heavy metals are seen though cadmium is not present. The traces of metals present in the treated water may be from the chemicals used for treatment of water.

The summary of the analysis of effluent is given in table 4.

The analysis report of the raw effluent samples RE_{14} and CRE and Treated Effluent TE_{15} and CCTE may be seen. There is reduction in pH. Except for minute presence of iron and Zinc, no other heavy metal is detected.

The summary of the analysis of solid waste samples collected from the factory is given in table 5.

The sludge transported as manure includes SS_{11} (light coloured from raw water treatment) SS_{12} (dark coloured lying in an area in the compound from where it is transported) and SS_{13} which is the effluent treatment plant sludge lying on sludge drying bed. Samples from the same spots were again taken during the second inspection and these samples are LS_2, CCS_2 and CES_2.

Cadmium concentration is found to be well within the limit in the above cases, the highest values of 36.7 mg/kg and 17.1 mg/kg were seen in the affluent treatment plant sludge lying in the sludge drying bed. The presence of any other heavy metal does not suggest the waste to be hazardous in nature.

The sludge thus collected during these inspections does not show any concentration of heavy metal to classify this as hazardous wastes. This could be owing to variation in production pattern. It is worthwhile to note that the Company was not in regular production at the time of inspection and may be this could be the reason for lower concentration and fluctuation of the heavy metals in the sludge. Hence a further study has to be carried out while the company is in full production.

10.4 Well water samples

The summary of the analysis report of the well water samples collected during the study is presented in the table 6.

The well water sample $CEW_{1,}$ $CEW_{2,}$ $CEW_{3,}$ CEW_4 are all from the eastern side of the factory and only in CEW_3 which is the common Panchayat well could a small quantity of cadmium (0.02 mg/l) be detected. This result does not hence show any heavy metal pollution of the wells on the western side due to working of the factory. The total hardness is found to be high in these wells (> 1000 mg/l) and this could be due to other natural reasons. The total hardness in the raw water used by the company is found to be less than the value detected in the wells outside the factory.

The well water samples taken from the western boundary ($CWW_{1,}$ CWW_2) shows only presence of copper manganese and zinc and that too of very low quantities. There is no presence of cadmium or lead in these well waters. The total hardness is found to be 820 mg/l and 1260 mg/l respectively. Similarly in the well of Shri Manikyam Chettiar who had used the sludge as manure only 0.01 mg/l of cadmium can be seen. The hardness here is 600 mg/l. The local people complained about appearance of milky sludge on heating the well water. The hardness of the well water seems to be the main cause for this phenomena.

11. Recommendations

The present study based on the two inspections cannot be called an exhaustive one. The variation in production pattern can alter the composition of the waste. The production pattern in the company was seen different during the Board’s inspection and sampling. The presence of low concentration of metals in the solid wastes shows that these might have arrived during production process as there is no noticeable heavy metals in the raw water. Further study during normal production is required to identify the source and fluctuation of heavy metals in the sludge.

The concentration of cadmium and other metals were found to be below the limit prescribed under Schedule 2 of the Hazardous Waste (Management and Handling) Rules 1989 as amended in 2003 and hence the solid waste generated in the company will not come under the purview of the Hazardous Wastes Rules. The solid waste generated in the factory is not advisable for applying on land for agriculture as manure. However, as utmost precaution, the company should handle the solid waste generated in the factory at Plachimada, following the procedures and safeguard prescribed under the Hazardous Waste (Management and Handling) Rules 1989 as amended in 2003.

Table-3 Analysis report of water sample taken from the factory premises

Sl. No	Description	Code	Concentration in mg/kg											
			Cd	Cr	Cu	Fe	Pb	Mn	Ni	P	Zn	As	PH	T Hard ness
1.	Raw water from containers	RW_9	BDL	BDL	BDL	BDL	BDL	BDL	0.14	BDL	BDL	BDL	7.1	
2.	Raw water from storage ponds	RW_{10}	BDL	BDL	BDL	BDL	266	BDL	BDL	BDL	BDL	BDL	6.9	
3.	Raw water from storage tanks	CRW	BDL	BDL	0.04	BDL	288	BDL	BDL	BDL	0.03	BDL	7.4	840
4.	Raw water from tube wells	CPR W	0.01	BDL	BDL	BDL	BDL	BDL	BDL	BDL	0.01	BDL	7.4	970
5.	Treated water	TRW	BDL	0.06	0.03	1.1	0.05	0.10	0.08	BDL	0.04	BDL	7.2	70

Table-4 Analysis report of effluent samples taken from the factory premises

Sl. No	**Description**	**Code**	**Concentration in mg/kg**											
			Cd	Cr	Cu	Fe	Pb	Mn	Ni	P	Zn	As	PH	T Hard ness
1.	Raw effluent-1	RE_{14}	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	0.5	BDL	7.5	
2.	Raw effluent-2	CRE	BDL	BDL	BDL	0.08	BDL	BDL	BDL	BDL	0.04	BDL	10.1	110
3.	Treated effluent-1	TE_{15}	BDL	BDL	BDL	0.2	BDL	BDL	BDL	BDL	0.72	BDL	7.4	
4.	Treated effluent-2	CCTE	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	7.5	870

Table-5 Analysis report of sludge samples collected from factory premises

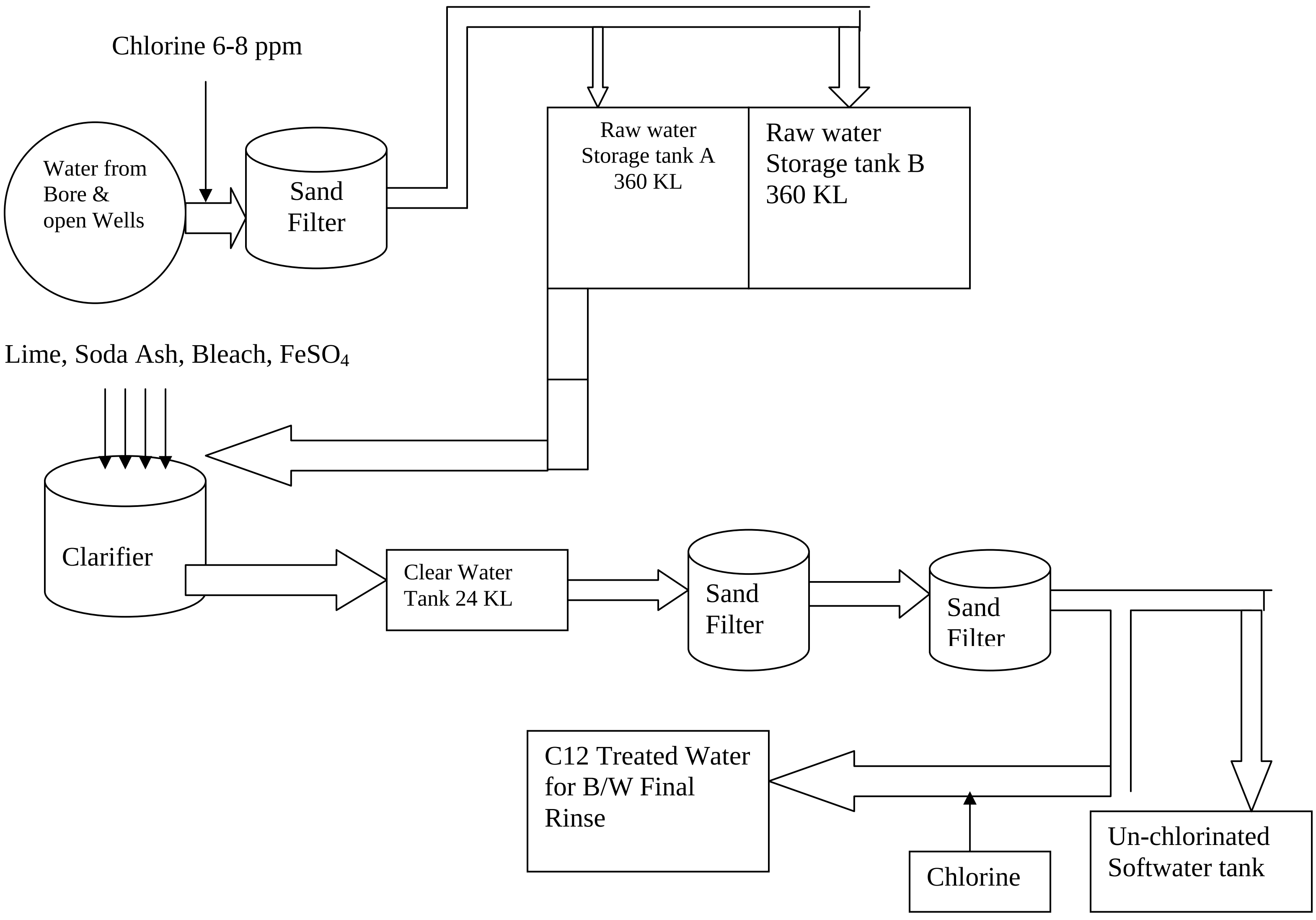
Sl. No	Description	Code	Concentration in mg/kg									
			Cd	Cr	Cu	Fe	Pb	Mn	Ni	P	Zn	As
1.	Raw water treatment sludge-1	SS_{11}	5.4	4.9	12.9	745	67	56.6	44.3	BDL	56	BDL
2.	Sludge from sugar cleaning-1	SS_{12}	2.3	BDL	11.7	309	44	29.7	3.3	2.0	141	BDL
3.	ETP sludge-1	SS_{13}	17.1	164.5	176	872.7	297	88.8	31.4	4.0	399	BDL
4.	Raw water treatment sludge-2	LS_2	7.0	40.1	20.7	2900	82	26	18	0.10	84.3	BDL
5.	Sludge from sugar cleaning-2	CCS_2	BDL	31.0	14.1	1100	BDL	4.5	2.5	BDL	148	BDL
6.	ETP sludge-2	CES_2	36.5	296	115	2900	401.4	68.6	23	3.3	365	BDL

Table-6 Analysis report of well water samples collected from outside the factory premises

Sl. No	Description	Code	Concentration in mg/kg											
			Cd	Pb	Cr	Cu	Fe	Mn	Ni	Zn	P	As	pH	T Hardness
1.	Eastern side Pazhavanal's house	CEW_1	BDL	BDL	BDL	0.05	0.08	0.04	0.10	0.14	BDL	BDL	7.1	1510
2.	Eastern side Subramaniam's house	CEW_2	BDL	BDL	BDL	BDL	BDL	BDL	0.08	0.16	BDL	BDL	7.2	1380
3.	Eastern side Panchayat well	CEW_3	0.02	BDL	BDL	0.04	BDL	0.05	BDL	0.08	BDL	BDL	7.1	1110
4.	Eastern side bore well	CEW_4	BDL	BDL	BDL	BDL	BDL	BDL	0.04	0.15	BDL	BDL	7.2	1110
5.	Western side Plachimada colony	CWW_1	BDL	BDL	BDL	BDL	BDL	BDL	BDL	0.03	BDL	BDL	7.8	820
6.	Western side Arusami's house	CWW_2	BDL	BDL	BDL	0.03	BDL	0.04	BDL	BDL	BDL	BDL	6.9	1260
7.	Manikyam Chettiar's house	WW_1	0.01	BDL	BDL	0.06	BDL	BDL	BDL	BDL	0.05	BDL	7.2	600

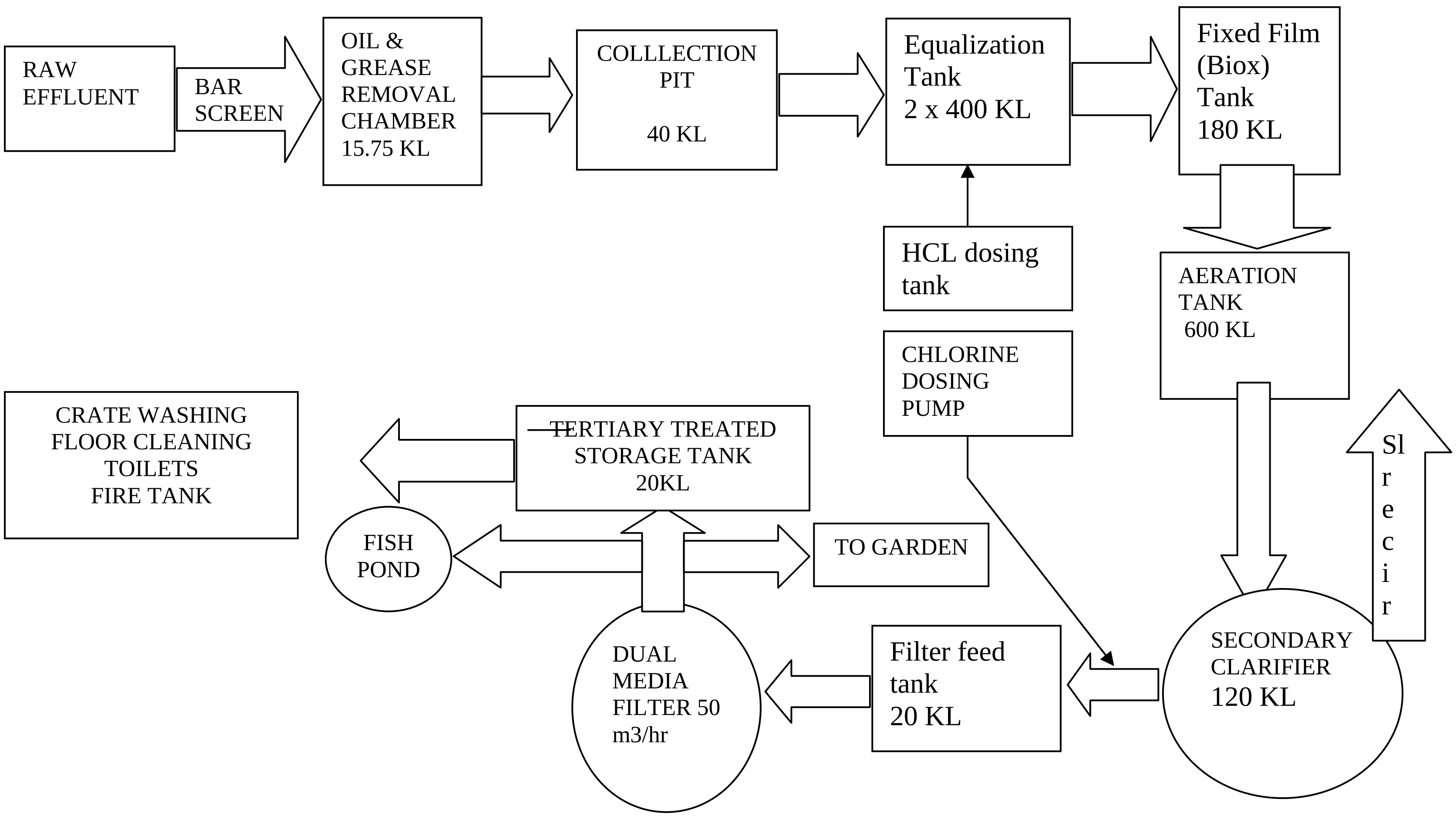
WTP – SOFT WATER PROCESS MAP

ANNEXURE-I



EIP OPERATION

ANNEXURE II



KERAL STATE POLLUTION CONTROL BOARD
CENTRAL; LABORATORY, KOCHI –20

ANALYSIS REPORT OF SLUDGE & WATER SAMPLES
Source Hindustan Coca-Cola Beverages Pvt. Ltd., Palakkad., Received from the Member Secretary on 29/8/03
Unit Metals-mg/l (water samples), mg/kg (Sludge samples in Dry weight)
Heavy metals Result:

Sl#	Sample#	Cadmium	Lead	T.Chromium	Copper	Iron	Manganese	Nickel	Zinc	Phosphorus	Arsenic
1.	AS1	0.50	18.0	70.4	23.6	1220	8.0	6.5	46.3	BDL	BDL
2.	LS2	7.0	82.0	40.1	20.7	2900	26.0	18.0	84.3	0.10	BDL
3.	CCS2	BDL	BDL	31.0	14.1	1100	4.5	2.5	148	BDL	BDL
4.	CES2	36.5	401.4	296.0	115.0	2900	68.6	23.0	365.0	3.3	BDL
5.	CEW1	BDL	BDL	BDL	0.05	0.08	0.04	0.10	0.14	BDL	BDL
6.	CEW2	BDL	BDL	BDL	BDL	BDL	BDL	0.08	0.16	BDL	BDL
7.	CEW3	0.02	BDL	BDL	0.04	BDL	0.05	BDL	0.08	BDL	BDL
8.	CEW4	BDL	BDL	BDL	BDL	BDL	BDL	0.04	0.15	BDL	BDL
9.	CWW1	BDL	BDL	BDL	BDL	BDL	BDL	BDL	0.03	BDL	BDL
10.	CWW2	BDL	BDL	BDL	0.03	BDL	0.04	BDL	BDL	BDL	BDL
11.	WW1	0.01	BDL	BDL	0.06	BDL	BDL	BDL	BDL	0.50	BDL
12.	CEW	BDL	BDL	BDL	0.04	BDL	BDL	BDL	0.03	BDL	BDL
13.	TRW	BDL	0.05	0.06	0.03	1.1	0.10	0.08	0.04	BDL	BDL
14.	CPRW	0.01	BDL	BDL	BDL	BDL	BDL	BDL	0.01	BDL	BDL
15.	CRE	BDL	BDL	BDL	BDL	0.08	BDL	BDL	0.04	BDL	BDL
16.	CCTE	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL

Result of General Parameters of Water Samples

Parameter	CEW1	CEW2	CEW3	CEW4	CWW1	CWW2	WW1	CRW	TRW	CPRW	CRE	CCTE
pH	7.1	7.2	7.1	7.2	7.8	6.9	7.2	7.4	7.2	7.4	10.1	7.5
T Hardness (mg/L)	1510	1380	1110	1100	820	1260	600	840	7.0	970	110	870
TOX (µg/L)	-	-	-	-	-	-	-	161.8	7.91	-	-	-

SENIOR ENVIRONMENTAL SCIENTIST

KERAL STATE POLLUTION CONTROL BOARD
CENTRAL; LABORATORY, KOCHI –20

ANALYSIS REPORT OF SLUDGE & WATER SAMPLES

Source M/s PepsiCo India Holding Pvt. Ltd., Palakkad., Received from the Member Secretary on 29/8/03

Unit Metals-mg/l (water samples), mg/kg (Sludge samples in Dry weight)

Heavy metals Result:

Sl#	Sample#	Cadmium	Lead	T.Chromium	Copper	Iron	Manganese	Nickel	Zinc	Phosphorus
1.	PSS1	15.3	25.0	63.2	64.7	2353	23.0	21.0	57.5	0.15
2.	PACL	0.2	12.0	87.1	18.8	1616	9.0	5.5	37.5	0.85
3.	PDAP1	10.1	23.0	159.2	47.5	1788	18.0	12.0	249.0	0.1
4.	PLS2	6.7	88.0	49.7	6.8	1300	38.0	26.0	369.0	BDL
5.	PES2	109.5	250.0	119.5	25.7	2926	114.0	65.0	340.0	2.8
6.	PCS1	1.1	42.0	43.4	97.2	2553	26.0	14.0	59.6	BDL
7.	PAS	BDL	0.12	BDL	BDL	BDL	BDL	BDL	0.21	BDL
8.	PTRW	BDL	BDL	BDL	0.03	BDL	0.08	0.10	0.41	BDL
9.	PRW	BDL	0.10	BDL	BDL	BDL	0.04	BDL	0.33	BDL
10.	PRE	0.01	0.05	BDL	BDL	BDL	BDL	BDL	0.20	BDL
11.	PTE	0.02	0.11	BDL	BDL	BDL	BDL	BDL	BDL	1.10
12.	PPRW	0.01	0.05	BDL	0.04	BDL	BDL	BDL	0.85	0.31
13.	PCE	BDL	0.13	BDL	BDL	0.10	0.04	BDL	0.28	1.35

The Arsenic value above all samples are BDL.

Result of General Parameters of Water Samples

Parameter	PTRW	PRW	PRE	PTE	PPFW	PCE
PH	8.8	7.1	8.8	8.1	8.0	7.9
T Hardness (mg)/L)	220	510	230	6.10	660	630

Sl. No 1 to 6 – Sludge samples & 7 to 13-Water Samples

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