INTERNATIONAL JOURNAL OF PLANT, ANIMAL AND ENVIRONMENTAL SCIENCES

IJPAES

Volume-3, Issue-4, Oct-Dec-2013 ISSN 2231-4490

www.ijpaes.com

Received: 19th August-2013 Revised: 27th Sept -2013 Accepted: 30th Oct-2013

Research article

ASSESSMENT OF IMPACT OF SOLID WASTE DUMPING ON SURFACE WATER SYSTEMS AT SURYAPET, ANDHRA PRADESH IN INDIA

Dr. K.Ravindra Chary

Lecturer, Department of Chemistry, S.V. College, Amaravadi Nagar, Suryapet-508 213, Andhra Pradesh, India Email: ravindracharykanchaanapally@gmail.com

ABSTRACT: Water samples from the three water sources flowing through water bodies with a few solid waste dump nautars in the Suryapet municipality in Andhra Pradesh have been analyzed for Cd, Pb, Cu, Zn and Mn contents in six months; Coliform bacteria and helminth eggs. Other water quality parameters such as BOD, DO, suspend solids and turbidity has also been evaluated. Cd, Pb, Zn, Mn and Cu flame have been confirmed using flame atomic absorption spectrometry (FAAS). Faecal coryforms, whole coliformes and helmith eggs are determined by the MF filter method (MF). Water samples Cd, Pb and Mn at different levels; Zn and Cu levels are low and in many cases the device's level of recognition levels are lower. Helminth egg counts are high in water samples; Water sources indicate that it is contaminated with pathogens. The main sources of pollutants in water resources are organic waste, as well as coliform bacteria collected from these waste dumps. Water resources are unsecured for both Pullareddy tank and Chaudhary tank for primary and secondary contact.
Key words: Contamination, Pathogen, Solid Waste, Water Tanks

INTRODUCTION

Solid Waste Management (SWM) is a complex issue throughout the world. In developed countries the issues of SWM (collection, transportation and disposal) are well understood, accepted and workable. However, solid waste management is one of the many problems con-fronting many developing countries and recent events in major urban centers have shown that the problem of waste management has become too complex to handle and has seen dwindling efforts of city authorities, federal governments, state and professionals alike in addressing the issue [1]. N'dow, (1996) [2] pointed out that by the year 2000, half of humanity will be living in urban areas where most economic activities will take place and where most pollutants will be generated and natural resources consumed. The problem of waste in urban cities of India can be better understood in the light of rapid urbanization and for the first time in the history of mankind, we are witnessing an unprecedented phenomenon in the development of places of habitat making the balance of human settlement patterns shift from more people inhabiting rural areas to more people living in cities [3,4]. This is 1500 metric tons of municipal solid waste daily representing about 75% of solid waste generated. The remainder ends up at community dumps in open spaces, in water bodies, beaches and storm drainage channels. Only a few solid waste derived from the Suryapet muncipality will recycle the informal sector without any support from the authorities. This indicates especially so in developing countries such as India, China and Pakistan. Although urbanization is not a new phenomenon, the current rate of uncontrolled and unpredictable urbanization has led to a large amount of liquid and solid waste production. These wastes have long been a long time to collect the capacity of city officials to take them safely and efficiently.

As per estimates more than 55 million tons of MSW is generated in India per year; the yearly increase is estimated to be about 5%. It is estimated that solid waste generated in small, medium and large cities and towns in India is about 0.1 kg, 0.3 – 0.4 kg and 0.5 kg per capita per day respectively. The estimated annual increase in per capita waste generation is about 1.33 % per year.

Composition of MSW Generated in Indian Cities

In India, the biodegradable portion dominates the bulk of MSW. This is mainly due to food and yard waste. With rising urbanization and change in lifestyle and food habits, the amount of municipal solid waste has been increasing rapidly and its composition has been changing [Fig.1] [5]

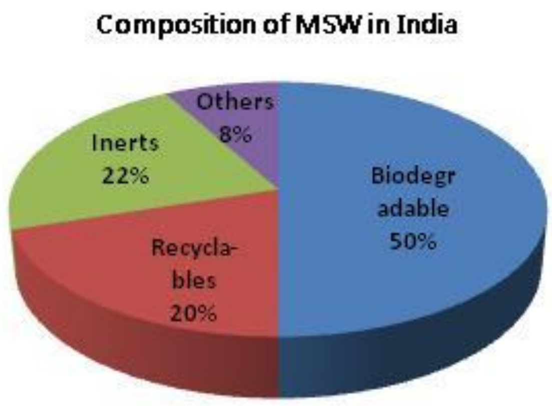

Figure 1: Composition of MSW in India

According to the Environmental Protection Agency (EPA) report, by 2025, this figure is expected to increase to 1.8 million tons per year or 4000 metric tons per day. The Suryapet Munciplaity Corporation (SMC) is solely responsible for municipal solid waste management in the town and is able to collect through its private partners sector without any support from the authorities. This indicates an overwhelming dependence on landfill as waste disposal option, the least preferred waste management option on the waste management hierarchy [6]. The design and optimization of solid waste management technologies and practices that aim at maximizing the yield of valuable products from waste as well as minimizing the environmental effects have little or no consideration in the Asian region. In the major cities of India (Mumbai, New Delhi, Calcutta and Hyderabad) open dumps were the means of solid waste disposal. It was under the World Bank's Urban Environmental Sanitation Project that India developed plans to build her first sanitary landfills in these four major cities. Many issues concerning landfill operation are not covered (mentioned) within the present guidelines simply due to the fact that they are already described in detail in the ISWA guidelines for landfill operation [7]. The problem of solid waste management in the Suryapet has been characterized by single and ad hoc solutions such as mobilizing people to collect waste and desilt choked gutters after a flood disaster or for an occasion, temporal allocation of waste contracts and dumping or building a central solid waste composting site.

It is a common site seeing water bodies flowing through most of these solid waste dump sites. Three prominent water bodies which are found flowing through some of these solid waste dump sites have been studied in order to ascertain the effects of the dump sites on water quality of these river sources. It is a known fact that virtually all water pollutants are hazardous to humans as well as lesser species. For example, sodium is known to cause cardiovascular disease while nitrates are involved in blood disorders. Mercury and lead are also widely known to cause nervous disorders. Some other contaminants are carcinogens while others. For example, DDT is known to be toxic to humans and can also alter chromosomes. Other such as, PCBs cause liver and nerve damage, skin eruptions, vomiting, fever, diarrhea, and fetal abnormalities. These known effects therefore support the need to assess the effects of these dumpsites on the water quality of these water resources which are widely in use by the communities leaving around them.

MATERIALS AND METHODS

Profile of the Study Area

The Suryapet Town is located in Eastern part of the Nalgonda district. The Suryapet revenue area covers Kesaram, Kasarabad, Imampet, Tallakammampadu, Circlepet, Pillalamarri, Choudari Tankmla, Ramannaguda, Tekumatla, Venkatrampur, Pinnaipalem, B-Dacharam villages. The location of the Suryapet Town falls under Survey of India Toposheets No 56O/12 and the geographical co-ordinates of the lease area as follows: North-West Corner: 17°09' 31.56" (Latitude), 79°36' 37.85" (Longitude), South-East Corner: 17°07' 57.46" (Latitude), 79°37' 55.82" (Longitude). The 10 km buffer Zone of the Suryapet is falling in 56O/12 SOI top sheet. The buffer zone is covered in Suryapet, Chivvemla, Kethapalle, Atmakur, Penpahad and Vemulapalle mandals of Nalgonda District [8].
The map of the study area is presented in Fig. 2 (Courtesy:*www*.mapsofindia.com) [9].

Figure 2. Map of the study area showing the sampling points.

Demography of Suryapet

Suryapet town in Nalgonda District has historical recognition as gateway of Telangana and Andhra regions of Andhra Pradesh. Nickname is Bhanupuri. It is lies on the NH 65 and equidistant of the Hyderabad and Vijayawada. Suryapet is India's first waste-complacent city, and Best municipality award by central govt. Suryapet town area 54 sq.km, population (2011)-105250, sex ratio is 1000:932. Literacy-85% and climate is tropical climate. Avg. annual rain fall is 1821 mm and avg. Temp 32°C. Town area is mainly hard gravel soils. Natural slop of the town is from North to South. Suryapet Divison Occupation is Main Agriculture; Musi left canal passes through this buffer from West to East.

Collection of Water Samples

Sampling of water from the study area was done over a period of six months (April-September, 2012). Summer season samples were obtained in April, May and June while Rainy season samples were collected in July, August and September. The locations of the sampling sites were established using a Garmin 45 Ground Positioning System (GPS).

At each sampling point, two sets of water samples were collected into separate pre-cleaned 1 L polyethylene bottles. 2.0 mL of concentrated HNO_3 was added to one of the bottles. The acidified sample was used for elemental analysis [9]. The non-acidified sample was analyzed for biological characteristics. Collected samples were stored in a cooler containing ice cubes, and later transported to the laboratory at the Department of Chemistry, KRR Govt. Arts & Science College, Kodad, for analysis. At the laboratory, samples were stored in refrigerators at 4˚C until analysis.

Apparatus and AAS Measurement Conditions

An atomic absorption spectrometer (Analyst 400, Perkin Elmer) was used for the determination of the concentrations of Cd, Pb, Zn, Mn and Cu. Boosted Cd, Pb, Zn, Mn and Cu hollow cathode Super lamps (Photron, Australia) were employed as radiation sources. The operating conditions of the spectrometer for the determination of Cd, Pb, Zn, Mn and Cu are presented in Table 2.

Chemicals, Reagents, and Standards

HNO_3 (Merck, Germany); H_2O_2 (30%, Merck, Germany), were used for mineralization of the samples. Standard stock metal solutions were prepared from Cd stock standard solution (1000 mg/L in 2.0% HNO_3, TraceCERT®, Fluka, Switzerland), Pb stock standard solution (1000 mg/L in 2.0% HNO_3, Trace CERT®, Fluka, Switzerland), Mn stock standard solution (1000 mg/L in 2.0% HNO_3, TraceCERT®, Fluka, Switzerland), Cu stock standard solution (1000 mg/L in 2.0% HNO_3, Trace CERT®, Fluka, Switzerland), and Zn stock standard solution (999 mg/L in 1.4% HNO_3, Teknolab AB, Sweden) respectively.

For all dilutions, demineralized redistilled water was utilized. Calibration curves were developed by using calibrants prepared by appropriate dilution of the 1.0 $g{\cdot}L^{-1}$ stock solutions to the required concentration with 2.0% HNO_3. The working standard metal solutions were pre-pared daily.

Table 1. The AAS operating parameters for the five elements determined

Element			**Operating conditions**	
Wavelength slit width				Flame
lamp current				
(nm) (nm) (mA)			Fuel	Oxidant
			(Flow rate: 2 L·min–1) (Flow rate: 13.5 L·min–1)	
Cd 228.8	0.5	4	Acetylene	Air
Pb 217.0	1.0	5	Acetylene	Air
Zn 213.9	1.0	5	Acetylene	Air
Mn 279.5	0.2	5	Acetylene	Air
Cu 324.8	0.5	4	Acetylene	Air

Detection limits for the five elements: Cd: 2.0 µg/l; Pb: 3.0 µg/l; Zn: 2.0 µg/l; Mn: 3.0 µg/l; Cu: 4.0 µg/l.

Cd, Pb, Zn, Mn, and Cu Measurements by AAS

Determination of metals in the acidified filtered (0.45 µm Millipore filter) water samples were carried out in accordance with standard methods [10,11]. The concentrations of Cd, Pb, Zn, Mn and Cu in the samples were respectively estimated by comparison with either the respective calibration curve or by the standard addition technique.

Physical and Chemical Measurements

Temperature, pH and dissolved oxygen were measured in-situ and recorded at the sampling sites. Nitrates, phosphates and physical parameters such as Biochemical Oxygen Demand (BOD_5), turbidity and suspended solids were also determined using standard methods [12].

Determination of Biological Characteristics

Total coliforms and Faecal coliforms were determined by membrane filtration method using M-Endo-Agar at 37˚C and on MFC Agar at 44˚C ± 0.5˚C for 48 hours, respectively.

All species of helminth eggs in water samples were quantified using the concentration method [13]. The identities of the specific helminth eggs were established using the World Health Organization (WHO) bench aid for the diagnosis of intestinal parasites [14].

RESULTS AND DISCUSSIONS

Physical Parameters

The physical parameters of water quality can be broken down into many topics and one need to take into consideration the nature of the physical parameters of the ecosystem surrounding a water source to be able to understand the physical appearance of water. Physical parameters which usually determine water quality are considered below.

Temperature of Water

Temperature affects sediment and microbial growth among other characteristics of water and it is also a known fact that the rate at which chemical reactions occur increase with increasing temperature and the rate of biochemical reactions usually double for every 10.0˚C rise in temperature. Physically, less oxygen can dissolve in warm water than in cold water. This is because increased temperature decreases the solubility of gases in oxygen consumption and increased decomposition of organic matter [15]. It is for these reasons that the temperatures of the water samples were determined for the river systems. The mean seasonal water temperature ranged from 27.4˚C at Choudari Tank to 31.1˚C at Pullareddy Tank in the rainy season, Table 2 and 27.4˚C at Choudari Tank to 28.4˚C at Pullareddy Tank in the summer season, Table 2. Since water temperature affects the concentration of biological, physical, and chemical constituents of water, the relatively high temperatures recorded would speed up the decomposition of organic matter in the water. Hence, population of bacteria and phytoplankton would double in warm weather in a very short time [16].

pH of Water

pH is important in water quality assessment as it influences many biological and chemical processes within a water body [16]. The pH values recorded were slightly alkaline with little variations among the study sites. The seasonal mean values ranged from 7.6 at Pullareddy Tank to 7.8 at Nalla Tank in the rainy season, Table 2 and 7.6 at Pullareddy Tank to 7.74 at Choudari Tank in the summer season, Table 3. The mean values fell within the WHO acceptable limits of 6.5 - 8.5. However, most of the sampled sites had pH values slightly higher than natural background level of 7 for tropical surface water.

It is a known fact that variations in pH affect chemical and biological processes in water and low pH increases the availability of metals and other toxins for intake by aquatic life. On the other hand, the slightly high alkaline pH values recorded at the study sites would tend to de-crease the availability of metals and other toxins for intake by aquatic life as well as plants. The high pH may be due to the presence of other pollutants introduced into the water. As most of the study sites are located near landfills/dumpsites.

Table 2. Physico chemical characteristics of water samples for rainy season.

Sampling sites/Mean levels of parameters

Parameters	Choudari Tank	Nalla Tank	Pullareddy Tank
Temp. (˚C)	27.4	27.7	28.2
pH	7.7	7.8	7.6
Dissolved Oxygen (mg/l)	6.0	5.5	4.8
Biological Oxygen Demand (mg/l)	3.6	4.3	3.4
Suspended Solids (mg/l)	50.0	47.3	48.3
Turbidity (n.t.u)	33.6	39.9	32.0
Nitrate (mg/l)	2.1	2.2	2.2
Phosphate (mg/l)	0.4	0.2	0.2

Table 3. Physico-chemical characteristics of water samples for summer season.

Sampling sites/Mean levels of parameters

Temperature (˚C)	28.2	31.1	28.4
pH	7.8	7.7	7.6
Dissolved oxygen (mg/l)	5.8	5.8	4.8
Biological oxygen demand (mg/l)	4.0	4.5	3.7
Suspended solids (mg/l)	43.7	42.3	33.3
Turbidity (NTU)	27.9	39.0	40.2
Nitrate (mg/l)	2.1	1.9	2.0
Phosphate (mg/l)	0.2	0.2	0.2

Source: field survey (2012).

Turbidity

Turbidity (a term that refers to the optical property that causes light to be scattered and absorbed rather than transmitted in a straight line through water) in water is caused by suspended and colloidal matter such as clay, silt, finely divided organic matter, plankton and other microscopic organisms.

The mean seasonal values for this parameter ranged from 32.0 NTU at Pullareddy Tank to 39.9 NTU at Nalla Tank in the rainy season as can be seen in Table 2 and 27.9 NTU at Choudary Tank to 40.2 NTU at Pullareddy Tank in the summer season, Table 3. All the values recorded were higher than the WHO value of 5 NTU. The high turbidity value could be due to the slitting of the landfills/dumpsites close to the water bodies. It could also be due to indiscriminate disposal of waste into the water bodies.

Another possible cause of high turbidity values may be the siltation of the Nalla Tank, the Pullareddy Tank, Choudari Tank. Siltation of these rivers and the lagoon is one of the problems arising from the cultivation along the banks of the rivers and the lagoon. Most of the farms are situated very close to the banks of these water bodies and cultivation of the banks is intense especially during the summer season, when there is water scarcity. This therefore results in erosion. According to the EPA, (2002), turbidity values between 0.0 - 5.0 NTU show no visible turbidity, no adverse aesthetic effects and no significant risk of infectious disease transmission. Values > 10 NTU have severe aesthetic effects and the water carries an associated risk of diseases due to infectious agents and chemicals absorbed onto particulate matter [6].

Suspended Solids

Suspended solids consist of materials originating from the surface of the catchment area, eroded from river banks or lake shores and suspended from the bed of the water body [16]. Suspended solids include tiny particles of silts and clays, living organisms (zooplankton, phytoplankton and bacterioplankton) and dead particulate organic matter [17]. The seasonal mean values for suspended solids ranged from 47.3 mg/l at Nalla Tank to 50.0 mg/l at Choudari Tank in the rainy season, Table 2 and 43.7 mg/l at Pullareddy Tank to 33.3 mg/l at Choudari Tank in the summer season, Table 2.

The suspended solids values recorded were generally high. The extremely high values recorded at all the sam-pling locations could be due to the large quantity of decomposing matter as all the sites have landfills/dumpsites located near them. At all water samples, as evidenced in Fig. 2, aquatic microphytes are threatening to take over the lagoon. According to Lester and Birkett, (1999) [18], suspended solid values of less than 25 mg/l have no harmful effect on fisheries as indicated in Table 2.

One direct effect of suspended solids is the influence on the turbidity of the receiving water body. This in turn reduces the amount of light that can penetrate the water and therefore will tend to reduce photosynthesis. Moreover, this could affect the recreational use of the water body. Suspended solids may also exhibit an effect if they settle out of suspension. Deposition of solids can change the characteristics of the riverbed, which will in turn affect plant and animal growth and fish breeding. Suspended solids generally cause damage to fish gills affecting their oxygen consumption and ultimately causing death at high concentrations. There was a defined trend in seasonal variations as summer season values were higher than the rainy season values.

Table 4 The effects of suspended solids on fisheries.

Suspended Solids (mg/l) Effects
<25 No harmful effect
25-80 Some possible reduction in yield
80-400 Good fisheries unlikely
>40 Very poor or non-existent

Source: lester and Birkett (1999).

Chemical Parameters

Chemical characteristics of water can affect aesthetic qualities such as how water looks, smells, and tastes. This can also affect its toxicity and whether or not the water is safe to use. Since the chemical quality of water is important to the health of humans as well as the plants and animals that live in and around streams, it is necessary to assess the chemical attributes of water. It is in light of these facts that the following chemical parameters have been determined for the water systems.

Dissolved Oxygen

The amount of oxygen dissolved in water depends on the rate of aeration from the atmosphere, temperature, air pressure and salinity. While the actual amount of oxygen that can be dissolved in water depends on the relative rates of respiration by all organisms and of photosynthesis by plants, oxygen levels are actually low where organic matter accumulates because aerobic decomposers require and consume oxygen. The mean seasonal values dissolved oxygen values of the waters ranged from 4.8 mg/l at Pullareddy tank to 6.0 mg/l at Choudari Tank in the rainy season, Table 2 but ranged from 4.8 mg/l at Pullareddy tank to 5.8 mg/l at Choudari Tank and Nalla tank during the summer season as is observed in Table 3. The DO values recorded at the locations compared with the natural background level of 7.0 mg/l were generally low. This low values give an indication of pollution at all the sampling sites especially at Pullareddy Tank. The major possible causes of the pollution would include contamination by leachates from the landfill sites and indiscriminate defaecation and dumping of refuse along the banks and into the water bodies. The influence of other human activities such as farming at the river banks, fishing, washing and bathing in the river cannot be ruled out.

According to Cunningham and Saigo, (1997) [19], the addition of certain organic materials to water stimulates oxygen consumption by decomposers. The dissolved oxygen falls as decomposers metabolize waste materials. Water with less than 2.0 mg/l will only support detritus feeders, decomposers and worms. The optimal DO concentration for growth of fisheries is 5.00 - 8.00 mg/l. The sites that fell within this range are Choudari Tank and Nalla Tank where some kind of fishing is done. All the other sites except Pullareddy tank which fell in the range lethal for tilapia had concentration for which growth of tilapia will be impaired [6].

Biochemical Oxygen Demand (BOD)

Biochemical Oxygen Demand (BOD) is used as an index for determining the amount of decomposing organic materials as well as the rate of biological activities in water. This is because oxygen is required for respiration by micro-organisms involved in the decomposition of organic materials. Thus high concentration of BOD indicates the presence of organic effluent and hence oxygen requiring micro-organisms.

Mean seasonal BOD for the water systems ranged from a minimum of 3.4 mg/l at Pullareddy tank to a maximum of 4.3 mg/l at Nalla Tank in the rainy season as in Table 2 and 3.7 mg/l at Pullareddy tank to 4.5 mg/l at Nalla Tank during the summer season, Table 3.

Indiscriminate defaecation and refuse disposal was observed at all the sampling sites. The slightly high BOD values may be attributed to the discharge of organic waste into water bodies resulting in the uptake of DO in the oxidative breakdown of these wastes [20]. The nearness of the sampling locations to landfill/dumpsites is a factor promoting the loading of the water bodies with organic matter hence, the high BOD values.

The implication of high BOD in surface water could also mean that the oxygen present in the water will be used for decomposition of the pollutants, and thus, is not available for aquatic life anymore. The natural back-ground level for freshwater ranges from 1.0 to 3.0 mg/l. The BOD of a river must generally not exceed 4.0 mg/l. This would reduce DO from saturating to 5.0 - 6.0 mg/l which is still capable of supporting aquatic life.

Nutrients

Nutrients mainly refer to inorganic matter from runoffs, landfills, livestock operation and crop lands, etc. The two primary nutrients of concern are usually phosphorus and nitrogen.

Nitrate

Nitrogen which usually exists in water bodies as nitrate is a key ingredient in fertilizers. It generally becomes a pollutant in saltwater or brackish estuarine systems where nitrogen is a limiting nutrient. Excess amounts of bioavailable nitrogen in marine systems lead to eutrophication and algae blooms. It is with regards to the key role nitrates play in water quality determination that its assessment has been under-taken in this study. As can be seen from Table 2, the mean seasonal values for the compound ranged from 2.1 mg/l at Choudary tank to 2.2 mg/l at Nalla Tank and Choudari Tank in the rainy season and 1.9 mg/l at Nalla tank to 2.1 mg/l at Choudari Tank in the summer season, Table 3. All the sites registered nitrate values higher than the natural background level of 0.23 mg/l. The nitrate concentrations were however lower than the WHO limit of 10.0 mg/l. The presence of nitrate may be the result of waste being disposed off at the land-fills/dumpsites. Thus, contamination of the water bodies with chemicals from the landfills/dumpsites is very likely to occur. This is because wastes from agro-based Industries which may contain nitrates are not segregated before disposal and are likely to find their way into the river systems in runoffs or leachate emanating from the landfills. It could also be attributed to run-offs from farms along the banks of the rivers which may contain organic fertilizers. There was a slight seasonal variation as the rainy season values were higher than the summer season values.

Nitrates are the most common form of nitrogen found in natural waters with enough dissolved oxygen. The natural background levels of nitrate may come from rocks, land drainage and plant and animal matter. Extremely high concentration of nitrate is toxic. However, the values recorded for all the sampling sites do not exceed the WHO limit value of 10.0 mg/l [21].

Invariably, nitrate is seldom abundant in natural surface water because it is incorporated into cells and chemically reduced by microbes and converted into atmospheric nitrogen [16]. This phenomenon may account for the low concentration of nitrate in surface waters.

Phosphate

Phosphorus is a nutrient that occurs in many forms that are bioavailable and phosphate is one such form of its existence. It is a main ingredient in many fertilizers used for agriculture as well as on residential and commercial properties, and may become a limiting nutrient in fresh-water systems. Phosphorus is most often transported to water bodies via soil erosion because many forms of phosphorus tend to be adsorbed to soil particles. Excess amounts of the element in aquatic systems (particularly freshwater lakes, reservoirs, and ponds) leads to proliferation of microscopic algae called phytoplankton.

Mean seasonal values of the element in this study ranged from 0.2 mg/l at Pullareddy Tank and Nalla Tank to 0.4 mg/l at Choudari Tank in the rainy season as can be seen in Table 2. The summer season mean values range from 0.2 mg/l at Choudari Tank, Pullareddy Tank and Nalla Tank in the summer season, Table 3. The phosphate concentrations were relatively high com-pared with the natural background level of 0.02 mg/l. With the exception of Choudari Tank, all the remaining sites Registered values not above the WHO limit of 0.3 mg/l. The high concentration may be due to the effect of seepage from the landfill/dumpsites into the water bodies. It can also be attributed to domestic waste water and agricultural run-offs. A high phosphate concentration is an indication of pollution. There was only minimal variation in the seasonal trend in this study.

Phosphorus is also an essential nutrient and can exist in water in both dissolved and particulate forms. It is vital to the production of living organisms in the aquatic environment. High phosphate concentration is responseble for the eutrophication of a water body as phosphorus is a limiting nutrient for algae growth. All polyphosphates are eventually hydrolysed to produce the ortho form and the rate of hydrolysis is increased by temperature, decreased pH and bacterial enzyme action [22].

Heavy Metals

Compounds including heavy metals like lead, mercury, zinc, and cadmium, and organics like polychlorinated biphenyls (PCBs) and polycyclic aromatic hydrocarbons (PAHs), fire retardants, and other substances are resistant to breakdown. These contaminants can come from a variety of sources including mining operations, vehicle emissions, fossil fuel combustion, urban runoff, Industrial operations and landfills.

These compounds can threaten the health of both humans and aquatic species while being resistant to environmental breakdown, thus allowing them to persist in the environment. These toxic chemicals could come from croplands, nurseries, orchards, building sites, gardens, lawns and landfills.

Lead (Pb)

Lead in the environment is mainly particulate bound with relatively low mobility and bioavailability. Lead does, in general, not bioaccumulate and there is no increase in concentration of the metal in food chains [23]. Lead is also not essential for plant and animal life. The mean values of the metal ranged from 32.0 µg/l at Nalla Tank to 44.0 µg/l at Choudari Tank in the rainy season, Table 5. The summer season values range from 35.0 µg/l at Nalla Tank to 72.0 µg/l at Choudari Tank as seen in Table 6.

The presence of lead in the water may be due to the discharge of industrial effluents from petroleum production [15]. Lead may also come from lead-acid batteries, plastics and rubber remnants, lead foils such as bottle closures, used motor oils and discarded electronic gadgets including televisions, electronic calculators and stereos [22] where leachates from the waste dumpsites may find their way into the rivers. All lead values fell between 32.0 µg/l to 72.0 µg/l. There are no adverse effects of exposure to water at these concentrations. The recommended range for livestock is 0.0 - 100.0 µg/l. All the sites had concentrations below 100.0 µg/l and therefore there are no health risk concerns. However, all the sites were above the general upper limit of 30.0 µg/l for continuous exposure for fish.

Copper (Cu)

The mean seasonal values of copper in water systems during the study period were below detection limit of 4.0 µg/l at all the study sites during the rainy season, Table 5. The summer season values ranged from below detection limit to 6.0 µg/l as captured in Table 6.

Water quality range for copper for which there is no health or aesthetic effect is 0.0 µg/l to 10.0 µg/l and all the sites fell within this range. All the sites where the water is used for irrigation also fell below the level for which copper is toxic to plants, 100.0 µg/l to 1000.0 µg/l. For fisheries, the level for which there are no adverse effects on early life stages of some species ranges from 2.0 µg/l to 60.0 µg/l, and all the sites fell below this range hence, copper levels in the river systems pose no threat to the environment and health.

Manganese (Mn)

Manganese occurs in surface waters that are low in oxy-gen and often does so with iron. When oxidized in aero-bic waters, the oxide builds up in distribution causing severe discolouration at concentrations above 50.0 µg/l [21]. The mean seasonal concentrations ranged from 130.0 µg/l at Nalla Tank to 240. 0 µg/l at Pullareddy Tank in the rainy season, Table 5. The summer season values ranged from 26.0 µg/l at Choudari Tank to 452.0 µg/l at Pullareddy Tank, Table 6.

The presence of manganese may be due to discharge from industrial facilities or as leachate from landfills [10]. The very high values of manganese may be as a result of pollution from manganese dioxide cells for which the nation has no controlled methods of disposal. The metal may also come from other sources such as domestic wastewater and sewage sludge disposal. There was no clearly defined trend in seasonal variations. All the sites registered mean values above the WHO limit of 10.0 µg/l.

Cadmium (Cd)

Cadmium is readily accumulated by many organisms, particularly by micro -organisms and mollusc where bio-concentration factors are in the order of thousands. Soil invertebrates also concentrate Cd markedly [24]. Chronic exposure to the metal produces a wide variety of acute and chronic effects in mammals similar to those seen in humans. Kidney damage and lung emphysema are the primary effects of high Cadmium in the body.

Mean values of the metal in this study ranged from 4.0 µg/l at Choudari Tank to a maximum of 10.3 µg/l at Pullareddy Tank in the rainy season, Table 5. The summer season values recorded ranged from 7.0 µg/l at Nalla Tank to 17.0 µg/l at Pullareddy Tank, Table 6. There was a defined trend as the summer season values obtained were higher than the rainy season values. Even though the values obtained are low, cadmium is known to be one of the most toxic elements with reported carcinogenic effects to humans [25]. High concentration of cadmium has been found to lead to chronic kidney days function. Cadmium may bioaccumulate at all levels of aquatic and terrestrial food chains. Cadmium contaminations in surface water bodies could be attributed to the discharge of contaminants including nickel-cadmium batteries. Some other activities which may introduce cadmium into these environments include electroplating and plastic manufacture.

Zinc (Zn)

Zinc levels were below the detection limits in all the waters sampled at the various sites. It is not clear why the very low level of the metal in the rivers despite the recorded values of zinc in the leachates from the dumpsites located close to the rivers [26]. This will need further investigation to ascribe reasons to the very low values of zinc.

Table 5. Levels of Zn, Cu, Pb Cd and Mn in surface water bodies for rainy season.

Sampling sites/Mean levels of metals (µg/l)

Parameters	Choudari Tank	Nalla Tank	Pullareddy Tank
Zinc	bdl	bdl	bdl
Copper	bdl	bdl	bdl
Lead	44.0	32.0	35.0
Cadmium	4.0	5.0	10.3
Manganese	186.0	130.0	240.0

Source: field survey (2012); (bdl = below detection limit).

Table 6. Levels of Zn, Cu, Pb Cd and Mn in surface water bodies for summer season.

Sampling sites/Mean levels of metals (µg/l)

Parameters	Choudari Tank	Nalla Tank	Pullareddy Tank
Zinc	bdl	bdl	bdl
Copper	bdl	5.0	bdl
Lead	72.0	35.0	41.0
Cadmium	8.0	7.0	17.0
Manganese	26.0	310.0	452.0

Source: field survey (2012); (bdl = below detection limit).

Bacteriological Parameters

Pathogens are bacteria and viruses that can be found in water and cause diseases in humans. Typically, pathogens cause disease when they are present in public drinking water supplies. Pathogens found in contaminated runoff may also contain parasitic worms (helminths). Coliform bacteria and faecal matter may also be detected in runoffs. These bacteria are a commonly used indicator of water pollution, but not an actual cause of disease.

Total Coliform (TC)

Total coliform gives a clear indication of the general sanitary condition of water since this group includes bacteria of faecal origin. However, many of the bacteria in this group may originate from growth in the aquatic environment. This is used to evaluate the general sanitary quality of drinking and related water use [6]. The mean total coliform population in this study varied between 6.0×10^4 cfu/100 ml at Nalla Tank and 94.0×10^4 cfu/100 ml at Pullareddy Tank in the rainy season. The summer season recorded a value of 2.3×10^4 cfu/100 ml at Nalla Tank to 94.7×10^4 cfu/100 ml at Choudary tank. There was a defined trend in the seasonal variations as the summer season values were generally higher than the rainy season values as indicated in Tables 7 and 8.

The high concentration of TC could also be due to in-discriminate defaecation, sewage, land and urban run-off and domestic waste waters [16]. The presence of coliform group of organisms is an indication of faecal con-tamination. The high TC counts observed at all the sam-pled sites make the river systems unsuitable for both primary contact, such as swimming and secondary con-tact such as boating and fishing according to the World Health Organization (WHO) limit [27].

Comparison of TC counts in the various sampled sites with the natural background and WHO limit of 0.0 cfu/100 ml indicated gross contamination with bacteria at all the sites making the water unsafe for drinking by hu-mans and livestock. According to UNICEF, (1999) [28], if water is found to contain faecal indicator bacteria, it is considered unsafe for human consumption.

Faecal Coliform (FC)

Bacteriological examinations of water samples are done to determine the sanitary quality and the degree of con-tamination with waste [12].

Faecal coliforms are bacteria that live in the digestive tract of warm-blooded animals. They are excreted in the solid wastes of humans and other mammals. Where fae cal coliforms are present, disease-causing bacteria are usually also present. Untreated faecal materials that contain faecal coliforms add excess organic material to the water. The decay of these materials depletes the water of oxygen which may result in killing of fishes and other aquatic life [29].

The mean values in our study ranged from 0.4 × 10^4 cfu/100 ml at Nalla Tank to 8.4 × 10^4 cfu/100 ml at Pullareddy Tank in the rainy season and the summer season values ranged from 0.6 × 10^4 cfu/100 ml at Nalla Tank to 11.1 × 10^4 cfu/100 ml at Choudari Tank as represented in Tables 6 and 7 respectively.

There was a clearly defined trend in the seasonal variations indicating higher values for the summer season than the rainy season. The high counts of faecal coliforms may be due to run-offs from the municipal landfills and urban solid waste disposal sites which contain domestic animal and human faecal materials [16]. It may also be attributed to indiscriminate refuse disposal along the banks of the water bodies.

The faecal coliform density was calculated using the formula:

$$\text{Colonies/100 ml} = \frac{\text{Colonies counted X 100 ml}}{\text{Sample volume (ml)}}$$

Helminths

Helminth eggs including *Ascarislumbricoides and Strongy-loidesstercoralis* were detected in the water samples. The helminth egg population ranged from 1 to 4 egg(s) 500 ml^{-1} in the water samples. The mean seasonal values are presented in **Tables 7** and **8**. The helminth egg in the samples might be due to the disposal of waste containing human and animal faecal materials at the disposal sites.

Table 7. Bacteriological parameters of water for the rainy season.

Sampling sites/Mean levels of biological parameters

Parameters	Choudari Tank	Nalla Tank	Pullareddy Tank
Feacal coliforms (CFU/100 ml) × 10^4	5.9	0.4	8.4
Total coliforms (CFU/100 ml) × 10^4	73.3	6.0	94.0
Helminth eggs/500 ml of water	2.3	1.5	1.3

Source: Field survey (2012).

Table 8. Bacteriological parameters of water for the summer season.

Sampling sites/Mean levels of biological parameters

Parameters	Choudari Tank	Nalla Tank	Pullareddy Tank
Feacal coliforms (CFU/100 ml) × 10^4	11.1	0.6	9.6
Total coliforms (CFU/100 ml) × 10^4	94.7	2.3	38.0
Helminth eggs/500 ml of water	0.6	0.5	3.3

Source: Field survey (2012).

CONCLUSION

The study revealed that the major pollutants into the Nalla Tank, Pullareddy Tank, Choudari Tank have been identified to be organic waste, total and faecal coliforms. The sources of these pollutants into these water bodies are through runoffs from the municipal land-fills/dump sites and could also be attributed to indiscriminate defaecation and refuse disposal which had contributed to elevated levels of the pollutants. Also, dumping and farming along the banks of these water bodies had led to eroded materials accumulating in them.

This has resulted in the occurrence of large quantities of suspended solids and ultimately high turbidities. The discharge of organic waste including human excreta, domestic and animal waste either directly or indirectly through runoffs, into the water systems has resulted in high BOD levels and subsequently, low levels of dissolved oxygen in the waters. The low level of dissolved oxygen recorded for the entire study period is an indication that the waters in the study area could not support life sufficiently.

The presence of the coliform group of organisms is an indication of faecal pollution. This is quite alarming considering the assertion by Pierce *et al.*, (1998) [15], that large numbers of coliforms in water is an indication of recent pollution by wastes from warm-blooded animals and therefore the water may contain pathogenic organ-isms. Even though the people in the study area do not depend solely on these water bodies as their sources of water supply, the spate of water shortages could turn the tide. The presence of these coliforms could be responsible for the transmission of infectious diseases which include typhoid fever, dysentery, salmonellosis, cholera and gastroenteritis which have been reported in the Accra metropolis. Heavy metals such as Cd, Pb, Mn, Cu and Zn analyzed in the water samples recorded varying levels of the metals. Heavy metals of public concern like Pb and Cd fell between 4.0 µg/l to 100 µg/l and were below the WHO recommended levels. There is therefore no threat to life in relation to the levels of these metals detected in the water bodies.

Helminth eggs and especially those of the genus Ascaris and Strongyloides families are the most commonly found in the water samples from the study area. However, there is no evidence of significant pollution with helminth ova that might pose a threat to humans especially those who have direct contact with the water.

REFERENCES

[1] A. Onibokun, "Governance and Waste Management in Africa," International Development Research Centre, Canada, 1999.

[2] F. N'Dow, "Sustainable Development," *Our Cities*, *Our Planet*, Vol. 8, No. 1, 1996, pp. 22-25.

[3] United Nations Population Fund, "The State of World Population," UNFPA Phoenix-Trykleriet AS, Denmark, 2001.

[4] J. Rabinovitch, "Global, Regional and Local Perspectives towards Sustainable Urban and Rural Development," Ashgate Publishing Ltd., London, 1998.

[5] http://www.eai.in/ref/ae/wte/typ/clas/msw.html

[6] https://www.epa.gov/landfills/municipal-solid-waste-landfills

[7] ISWA, (2010), Landfill Operational Guidelines – 2nd edition, International Solid Waste Association, Vienna, p. 106.

[8] Kota et al., Land Use/Land Cover Characteristics in and Around Suryapet Town, Nalgonda District for Urban Planning J Telecommun Syst Manage Volume 6 • Issue 1 ,2017, DOI: 10.4172/2167-0919.1000148

[9] A. F. Aiyesanmi and O. B. Imoisi, "Understanding Leach-ing behavior of Landfill Leachate in Benin-City, Edo State, Nigeria through Dumpsite Monitoring," *British Journal of Environment and Climate Change*, Vol. 1, No. 4, 2011, pp. 190-200.

[10] US Environmental Protection Agency (USEPA), "Innovative Uses of Composts," 2009. www.epa.gov

[11] APHA, "Standard Methods for the Examination of Water and Waste Water," 20th Edition, APHA, Washington DC, 1998.

[12] APHA, AWWA and WEF, "Standard Methods for the Examination of Water and Waste Water. 20th Edition, American Public Health Association (APHA), American Water Works Association, (AWWA), Water Environment Federation (WEF)," Washington DC, 1995.

[13] J. Schwartzbrod, "Consultancy Report Submitted to EAWAG/ SANDEC," 2000.

[14] WHO, "Guidelines for the Safe Use of Wastewater, Excreta and Grey Water," *Wastewater and Excreta Use in Aquaculture*, Vol. 3, World Health Organization, Geneva, 2006.

[15] J. J. Pierce, R. F. Weiner, and A. P. Vesihind, "Environ-mental Pollution and Control," 4th Edition, Butterworth-Heinemann Press, Boston, 1998.

[16] D. Chapman, "Water Quality Assessment. A Guide to the Use of Biota, Sediments and Water in Environmental Monitoring," 2nd Editon, E&FN Spon, New York, 1996.

[17] B. R. Davis and J. A. Day, "Vanishing Waters," University of Cape Town Press and Juta Press, Cape Town, 1998.

[18] J. N. Lester and J. W. Birkett, "Microbiology and Chemistry for Environmental Scientists and Engineers," 2nd Edi-tion, E&FN Spon, New York, 1999.

[19] W. P. Cunningham and B. W. Saigo, "Environmental Science: A Global Concern," 5th Edition, McGraw-Hill Publishers, Boston, 1999.

[20] S. B. Akuffo, "Pollution Control in a Developing Country: A Case Study of the Situation in Ghana," 2nd Edition, Ghana Universities Press, Legon, 1998.

[21] WHO, "Guidelines for Drinking-Water Quality, Volume 1: Recommendations. Geneva: WHO," 2009. http://www.who.int/water_sanitation_health/dwq/GDWQ 2004web.pdf

[22] WHO, "Environmental Chemistry," 2nd Edition, WH Freeman and Co., New York, 2004.

[23] WHO, "Lead-Environmental Aspects," Environmental Health Criteria 85, World Health Organization, International Programme on Chemical Safety (IPCS), Geneva, 1989.

[24] P. B. Woodbury, "Trace Elements in Municipal Solid Waste Compost: A Review of Potential Detrimental Effects on Plants, Soil Biota and Water," *Biomass and Bio-energy*, Vol. 3, 1992, pp. 239-259. doi:10.1016/0961-9534(92)90029-P

[25] IARC, "Cadmium and Cadmium Compound (Group)," *IARC Monograph*, Vol. 58, 1993, 25 p.

[26] V. K. Nartey, R. K. Klake, L. K. Doamekpor and S. Sar-pong-Kumankomah, "Speciation of Mercury in Mine Waste: Case Study of Abandoned and Active Gold Mine Sites at the Bibiani-Awianso-Bekwai Gold Mining Community of South Western Ghana," Environ Monit Assess, 2012.

[27] Millipore, "Water Microbiology," Laboratories and Field Procedures, Bedford, 1991.

[28] UNICEF, "Project Report: Study on Possible Pollution Caused by Water Seal Latrine to Ground Soil and Groundwater after 10 Years of Operation CEC," Univer- sity of Science, Hanoi National University, Vietnam, 1999.

[29] F. R. Spellman, and J. Drinan, "The Drinking Water Handbook," Technomic Publishing Co. Inc., Lancaster, 2000.