INTERNATIONAL JOURNAL OF PLANT, ANIMAL AND ENVIRONMENTAL SCIENCES
IJPAES

Volume-4, Issue-3, July-Sept-2014
ISSN 2231-4490

Coden : IJPAES www.ijpaes.com

Received: 11th May-2014 *Revised: 29th May-2014* *Accepted: 30th May-2014*

Research article

ASSESSMENT AND UTILIZATION OF GROUND WATER SAMPLES AS POTABLE WATER NEAR A DUMPING YARD OF NANDYAL, KURNOOL DISTRICT, ANDHRA PRADESH, INDIA

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ABSTRACT: Groundwater is an important source of water supply throughout the world. These sources are quite vulnerable to pollution and are irreversible and reclamation of polluted ground water sources is very difficult. Ground water samples were collected from the 10 different locations around the dumpsites of Nandyal, during January–February 2014. The quality was assessed in terms of physical–chemical parameters such as pH, TDS, EC, Turbidity, Total Hardness, Total Alkalinity, Chloride, Sulphate, Phosphate, Nitrate, Dissolved Oxygen, Fluoride, Calcium, Magnesium, Potassium and the metals like Copper, Zinc and Manganese using various analytical techniques. Faecal coliform were estimated in water samples collected from different sampling areas. It was found that the underground water was contaminated at few sampling sites which exceed the permissible limit of WHO Standards.
Key words: Ground water, Contamination, WHO, Dumpsites, Parameters.

INTRODUCTION

A water pollutant is a physical or chemical substance present in excessive levels capable of causing harm to living organisms On Public health concern the ground water should be free from physical and chemical hazards. The people in and around the dumping sites are depending upon the ground water for drinking and other domestic purposes. Safe drinking water is essential to human beings and other life forms. The daily demand of drinking water of a man is normally 7 % of his body weight. Thus, it becomes vital for the healthy growth of the persons. Access to potable drinking water has improved over the last decades in almost every part of the world, but approximately one billion people still lack access to safe water and over 2.5 billion lack accesses to adequate sanitation. However some observers have estimated that by 2025 more than half of the world population will be facing water based vulnerability [1]. Groundwater constitutes a huge percentage of global freshwater and thus becomes an important source of drinking water in many regions of the world [2, 3]. Ground water has long been considered as one of the purest forms of water available in nature and meets the overall demand of rural and semi-urban people [4]. Natural ground water is usually of good quality, but this can deteriorate due to inadequate source protection and poor resources management [5]. According to UNESCO report, a majority of Indian population has no access to safe drinking water and that about 66 million people rely on un-safe ground water for consumption [6]. In India, there are over 20 million private wells in addition to the government tube wells [7]. The wells are generally considered as the worst type of ground water sources in the term of physical – chemical contamination due to the lack of concrete plinth and surrounding drainage system [8]. Ground water pollution is mainly due to the process of industrialization and urbanization that has progressively developed over time without any regard for environmental consequences. Municipal solid waste disposal sites, primarily open dumping sites can potentially deteriorate the ecology of the surrounding area and pose a serious threat to water resources located in its vicinity. Disposal of this unwanted material is a monumental environmental problem with many dimensions [9].

STUDY AREA

Nandyal town is located at 1528´59. 880´´ N 7828´59. 880´´ E. Altitude of nandyal is 202 meters (Fig. 1). There are many oil factories located in Nandyal town and one sugar factory was established very near to Nandyal town. The study area is inhabitated with around 2,12, 640 populations.

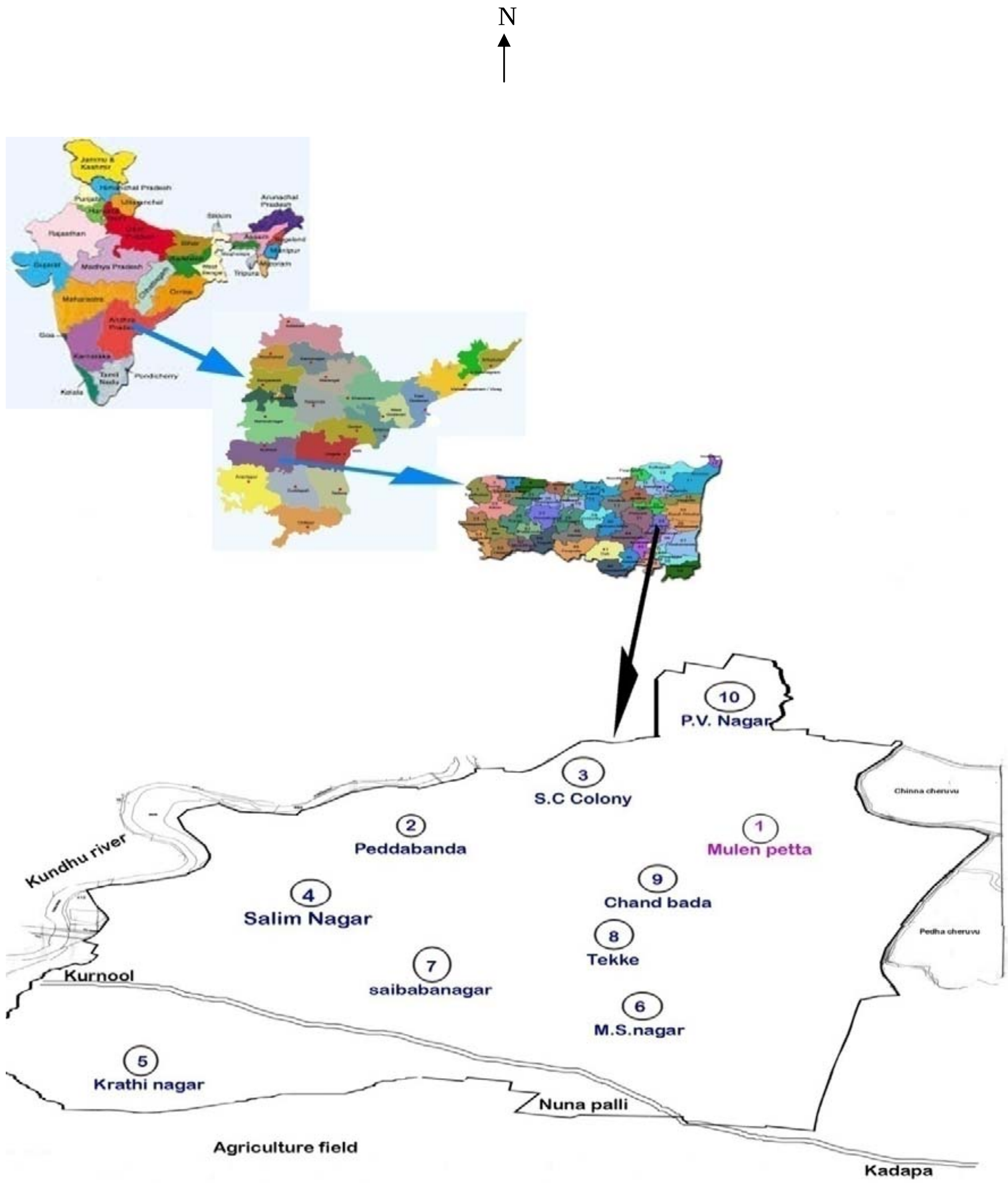

Figure 1 Map of Study area

MATERIALS AND METHODS

The samples are collected and stored in clean polythene bottles fitted with screw caps and the samples are kept as cool as possible without freezing. The samples were analysed for various water quality parameters such as pH, Temperature, Electrical conductivity (EC), Turbidity, Total Dissolved Solids (TDS), Dissolved Oxygen (DO), Total Alkalinity, Total Hardness, Chloride, Phosphate, Sulphate, Nitrate, Fluoride, Calcium, Magnesium, Potassium and the metals like Zinc, Copper and Manganese using standard procedures [10]. The methods used for estimation of various physical - chemical parameters are tabulated in Table 1. Coliform is a large group of diseases causing bacteria that inhabit the intestine of man and animals. Multiple Tube Fermentation was the technique used for MPN (Most Probable Number) count of coliforms.

Table 1. Methods used for estimation of Physical - Chemical Parameters

S. No	Parameters	Methods
1	pH	pH meter (Hanna)
2	Electrical Conductivity (µS/cm)	Conductivity meter (Hanna)
3	Turbidity (NTU)	Nephelometer (Elico)
4	Total Dissolved Solids (mg/L)	TDS Meter (Hanna)
5	Total Hardness (mg/L)	EDTA method
6	Total Alkalinity (mg/L)	Indicator method
7	Chloride (mg/L)	Silver nitrate method
8	Sulphate (mg/L)	Colorimetric method
9	Phosphate (mg/L)	Stannous chloride method
10	Nitrate (mg/L)	Phenol Disulphonic acid method
11	Fluoride (mg/L)	Orion ion – selective electrode method
12	Dissolved Oxygen (mg/L)	Winkler's method
13	Calcium (mg/L)	EDTA complexometric method
14	Potassium (mg/L)	Flame photometer
15	Cu, Zn and Mn (mg/L)	AAS (Avantha make)

RESULTS AND DISCUSSION

The results of the measured insitu parameters including pH, Temperature, Electrical Conductivity (EC), Total Dissolved Solids (TDS), Turbidity, Total Hardness, Total Alkalinity, Chloride, Sulphate, Phosphate, Nitrate, Fluoride, Dissolved Oxygen (DO), Calcium, Magnesium, Potassium, Copper, Zinc, and Manganese are shown in Table 2 & 3. The pH values of the ground water samples ranged from 7.11 to 7.77 which are within the permissible limits of WHO standards. Electrical Conductivity is a measure of total salt content in water. It's a determination of levels of inorganic constituents in water [11]. EC ranged from 790 to 4320 µS/cm which was found to be high except in S10. This high conductivity values obtained for the ground water near the dumpsite is an indication of its effect on the water quality. A similar result was reported in the analysis of ground water quality near the solid waste dumping site [12]. Highest concentration of EC was also reported in ground water of some villages of Dag block in Jhalawar district of Rajasthan State [13]. Temperature of ground water sample slightly varied ranging from 25.6 – 26.5. Turbidity of ground water samples ranged from 1.08 to 21.88 NTU. S1, S5, S7 and S8 values exceeds the drinking water norms proposed by the WHO. Total Dissolved Solids indicates the general nature of water quality or salinity. In this study TDS ranged between 354 to 2080 mg/L (Fig. 2 & 3) which exceeds the permissible limit. This may be due to the leaching of various pollutants into the ground water which decreases the potability and may also cause laxative effect during transits and gastro-intestinal irritation in humans [8]. Similar results were also reported in ground water at Jabalpur [14]. Total dissolved solid concentration between 723 to 2918 mg/L was observed in drinking water of Tiruchirapalli (Tamil Nadu) [15]. Total Hardness of the ground water samples were found to be in the range of 252.5 to 1160 mg/L which is further compared with the WHO standards of 300 mg/L. Highest values of hardness (840, 702 and 1160 mg/L) were recorded at the sampling sites S2, S4 and S5 respectively (Fig. 2 & 3). The study on impact of municipal solid waste on ground water in the environs of greater Visakhapatnam were observed. The total hardness in the Kapulauppada and Sukkavanipalem exceeded the permissible limits [16]. Water hardness is due to the multivalent metal ions, which comes from minerals dissolved in the water. However, some studies have shown a weak inverse relationship between water hardness and cardiovascular disease in men, up to a level of 170 mg calcium carbonate ($CaCO_3$) per litre of water [17, 18, and 19]. High concentration of hardness (150 to 300 mg/L and above) may cause kidney problems [20]. Total alkalinity was found to be in the range of 440 to1507 mg/L. All the samples had alkalinity concentrations above the WHO permissible limits. Whereas the chloride concentrations were far below (2.19 to 23.56 mg/L) WHO standard of 250 mg/L and are presented in Table 1 and Figure 2 & 3. Chloride salts in excess of 100 mg/L gives salty taste to water. The origin of chloride in water is due to the diverse source such as weathering and leaching of sedimentary rocks and soils, infiltration of seawater, domestic and industrial waste discharge, etc. Sodium sulphate and magnesium sulphate exert a cathartic action in the human being and also sulphate is associated with respiratory illness. Sulphate in the assessed ground water sample ranged from 20 to 1250 mg/L (Fig. 2 & 3). Highest concentrations of sulphate was found at the sampling sites S3, S4, S5, S6 and S7 respectively and are above the permissible limit (200 mg/L). This may be due to leachates from the unlined sewage drains, dumping of solid waste in an unscientific manner. The highest sulphate concentration in the ground water samples at Beed, Maharashtra were reported [21].

Phosphorus is usually present in natural water as phosphates (orthophosphates, polyphosphates and organically bound phosphates). Sources of phosphorus include human and animal wastes (i.e. sewage), industrial wastes, soil erosion and fertilizers.

Excess phosphorus causes extensive algal growth called "blooms," and lead to decreased oxygen levels in creek water. Phosphate in the ground water samples ranged from 25 to 200 mg/L which were found to be within the limits of WHO Standards. The common sources of nitrate in ground water are the leachate from the landfill sites, agrochemicals, sewage disposal, and improper disposal of domestic wastes etc. High concentration of nitrate causes methemoglobinemia (blue baby) in infants. NO_3^- at elevated concentration is also known to result in cyanosis in infants. Nitrate was recorded in the range of 0.18 to 3.92 mg/L (Fig. 2 & 3) and it was found within the desirable limit of 45 mg/L of WHO. Similar results were also reported in the ground water quality near Gazipur dumping site, Delhi [22].

Fluoride concentration were found to be very low in ground water and is considered beneficial. Fluoride has a significant mitigating effect against dental caries if the concentration is approximately one mg/L. However, continuous consumption of higher concentrations of 4 mg/L or more can cause dental fluorosis and in extreme cases even skeletal fluorosis [23].

Water that has low dissolved oxygen sometimes smells bad due to various pollutants in the water and the waste products produced by organism that live in such low oxygen environment. Very low dissolved oxygen concentration can result in mobilization of trace metals [24]. The concentration of dissolved oxygen in the ground water samples assessed varied between 1.68 to 9.68 mg/L (Fig. 2 & 3). D.O in S1 was not detected which indicates pollution around the dump – site and S10 being reasonably higher. The general trends of changes in DO concentration in different seasons are directly or indirectly governed by fluctuations of temperature and BOD. This may be due to the fact that the solubility of dissolved oxygen increases with decrease in water temperature.

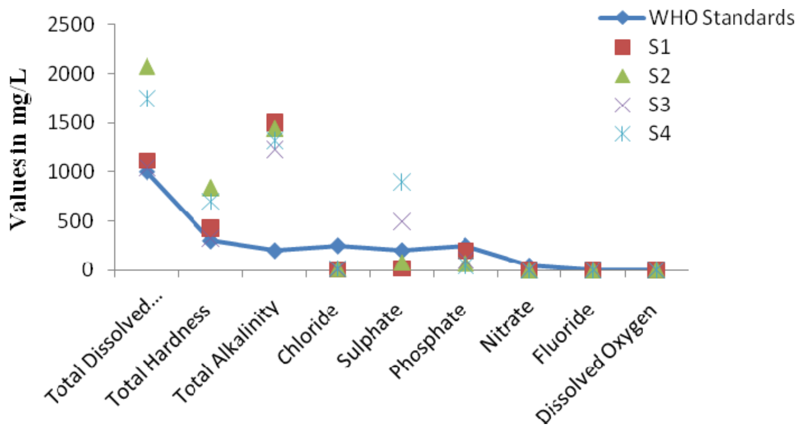

Figure 2

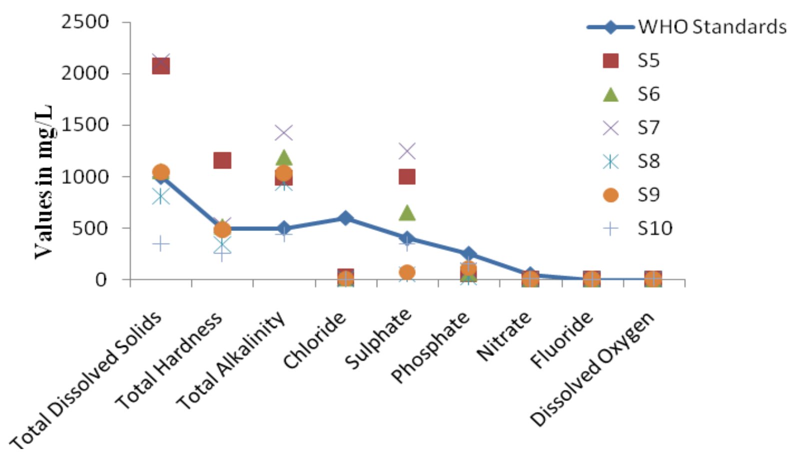

Figure 3

Calcium content is very common in ground water, because they are available in most of the rocks, abundantly and also due to its higher solubility. However, the range of its availability depends on the solubility of calcium carbonate and sulphate. The calcium concentration in ground water samples collected from this study area ranged from 20 to 68 mg/L and was found below the WHO standards (Fig. 4).

Magnesium (Mg^{2+}) contents range from 33.6 to 144 mg/L. The desirable limit of magnesium is less than 30 mg/L and it was observed that all the ground water samples exceeded the limit (Fig. 4). If the concentration of magnesium in drinking water is more than the permissible limit, it causes unpleasant taste to the water. Excess magnesium content causes scale formation in water thereby deteriorating its quality. Excessive intake of potassium may have laxative effect. In the present study, potassium concentrations were found in the range of 0.12 to 4.64 mg/L. Highest value of potassium (4.64 mg/L) was found at the sampling site S3. Current study showed that the concentration of potassium in natural waters is less, which is due to the relatively resistance of rocks to weathering that contains potassium [25].

Table: 2 Physical and Chemical characteristics of ground water samples around dump sites in the study area.

Parameters	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	WHO Standards
Temperature° C	26.5	26.4	25.8	25.7	26.1	25.5	25.8	26	25.6	25.9	24.5 -39.7
pH	7.28	7.55	7.29	7.11	7.16	7.15	7.77	7.61	7.69	7.52	6.5 -8.5
EC (µS/cm)	2132	3540	2151	3610	4320	1906	4300	1543	2159	790	1000
Turbidity (NTU)	15.4	3.04	5.28	1.52	14.8	1.08	21.88	6.32	1.12	5.8	5
Total Dissolved Solids (mg/L)	1116	2070	1042	1750	2080	1053	2120	813	1047	354	1000
Total Hardness (mg/L)	430	840	322.5	702	1160	515	530	340	485	252.5	300
Total Alkalinity (mg/L)	1507	1441	1232	1320	990	1188	1430	946	1034	440	200
Chloride (mg/L)	9.03	15.2	6.37	16.91	23.56	7.79	13.3	4.56	7.17	2.19	250
Sulphate (mg/L)	20	80	490	900	1000	650	1250	50	70	350	200
Phosphate (mg/L)	200	70	100	50	47.5	60	90	25	110	150	250
Nitrate (mg/L)	0.58	0.18	2.18	0.67	2.85	3.92	2.76	0.36	3.92	3.92	45
Fluoride (mg/L)	0	0.0059	0.0014	0.0172	0.0009	0.0007	0.0255	0.0014	0	0.0003	1.0
Dissolved Oxygen (mg/L)	0	5.12	1.68	2.55	6.0	2.16	2.88	4.64	2.96	9.68	4 - 6
Calcium (mg/L)	36	36	32	68	48	32	24	20	32	48	75
Magnesium (mg/L)	86.4	38.4	33.6	144	108	88.8	132	120	69.6	67.2	30
Potassium (mg/L)	1.72	2.69	4.64	0.51	0.55	0.20	0.31	0.74	0.12	0.12	15

Table 3.The concentration of trace metals ion in the ground water samples around dump sites in the study area.

Parameters	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	WHO Standards
Copper (mg/L)	0.48	0.36	0.56	0.29	0.45	0.50	0.60	0.27	0.36	0.42	0.03
Zinc (mg/L)	0.03	0.38	0.05	0.80	0.30	1.28	0.47	0.49	0.01	0.11	5
Manganese (mg/L)	0.002	0.003	0.004	0.002	0.002	0.003	0.003	0.020	0.002	0.001	0.1

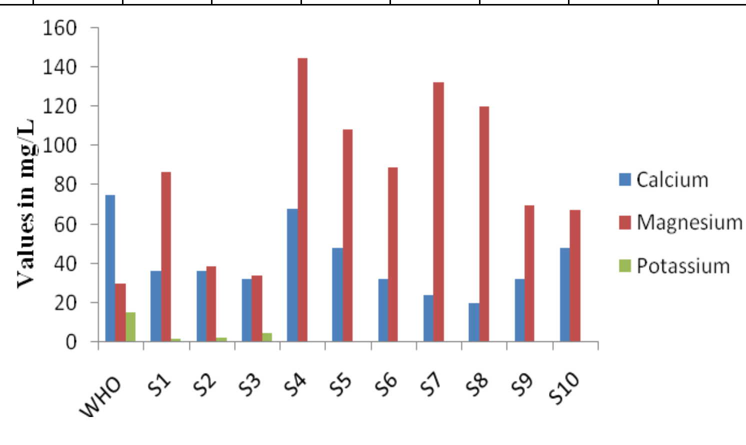

Figure 4

Copper produces an undesirable astringent taste, discoloration and corrosion of pipes, fittings and utensils if it exceeds the desirable limit of 0.03 mg/L. The present ground water samples showed the concentration of copper ranging between 0.27 to 0.60 mg/L. Thus the present study reveals that the ground water samples studied are contaminated due to copper and it is not suitable for drinking. Similar study was reported in ground water and soil quality nearer to Pallavaram solid waste landfill site [26]. Zinc belongs to a group of trace metals, which are essential for the growth of humans, animals and plants and are potentially dangerous for the biosphere when present in high concentrations [27]. Zinc concentrations were found to be from 0.01 to 1.28 mg/L and are below the WHO standards. Water containing more than 1 mg/L manganese may impart objectionable staining properties on clothes during laundry operations [28]. The present study showed that the manganese concentration ranged from 0.001 to 0.020 mg/L. Though these trace metals are needed by the body to satisfy its nutritional requirements, only minute quantities are required as high doses lead to health hazards which are sometimes lethal. The present investigation showed (Table 4) that the ground water quality from the point of view of potability is not safe. It exceeds the safe water quality standard i.e. one per 100ml depicting pollution of groundwater [29]. In Kanpur city ground water had coliform values exceeding the permissible limits for drinking purposes [30].

Table 4 Most probable number (MPN) of coliform bacteria present in 100 ml water, for various combinations of positive and negative results when three 10 ml portions, three 1 ml portions and three 0.1 ml portions are used.

Number of three tubes giving a positive reaction				
	10 ml	**1.0 ml**	**0.1 ml**	**MPN index/100 ml**
S1	2	0	0	9
S2	-	-	-	-
S3	3	1	0	43
S4	3	1	0	43
S5	-	-	-	-
S6	1	1	0	7
S7	-	-	-	-
S8	3	1	0	43
S9	3	1	1	75
S10	1	1	0	7

CONCLUSION

On the basis of current investigation we can conclude that the ground water near the Municipal Solid Waste dumping areas was found prone to contamination for some samples. All the samples are alkaline in nature. The moderately high concentration of EC, Total dissolved solids, Total hardness, sulphate and magnesium in ground water samples shows the deteriorated quality of the ground water which can be used only after treatment or purification by ion-exchange or reverse osmosis. The presence of zinc and manganese are within the limits of WHO standards whereas the concentration of copper is found to be susceptible. Most of the water sample showed contamination of water due to faecal coliforms which are higher in range than the recommended standards of WHO, 1984. The ground water near the dumping yard must be disinfected for domestic usage. Though, the concentration of few contaminants studied does not exceed the drinking water standard recommended by WHO, monitoring of the ground water in the adjoining areas of landfill dumping sites should me made mandatory in order to prevent ground water contamination. Further it becomes inevitable to dispose the solid waste in a scientific manner.

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