Effect of Leachate-contaminated Groundwater on the Growth and Blood of Albino of Rats

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Citation

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Abstract

The results of effect of daily consumption of leachate-contaminated groundwater for 65days on rats' Packed Cell Volume (PCV), Haemoglobin (Hb), White Blood Cell (WBC), Red Blood Cell (RBC), neutrophil and platelet are presented. The PCV (%) of rats treated with leachate was found to be 26±4 while that of animals treated with control tap water was 40±2. Hb (g/dl) of control rats was observed to be 14.3±0.3 while that of leachate treated rats was 10.9±0.3. The experimental results indicated that consumption of leachate-contaminated groundwater may lead to ill health particularly anaemia.

INTRODUCTION

Pollutants can escape from improperly designed landfill in a variety of ways (Carla, 2000). If soil above or below a landfill is permeable, leachate can escape to contaminate groundwater (Carla, 2000). Recent studies indicate that small landfills (waste volume up to 50,000yd ^{3}) may impact groundwater (Friedman, 1988 and Bagchi, 2004).

Once the groundwater is polluted, the pollution may be difficult to correct or even to detect. Carla (1997) predicted that in the next few decades, more contaminated aquifers will be discovered, new contaminants will be identified, and more polluted groundwater will discharged into wetlands, streams, and lakes as this groundwater passes through the hydrologic cycle. By the time groundwater pollution is detected, it may be very widespread, and the exact extent of the problem may not be readily determined without the drilling of many monitoring wells across the affected area (Bagchi, 2004). Even the source can be hard to identify unless the chemistry of the contamination is distinctive (Carla, 1997).

Contaminants carried in leachate are dependent on solid waste composition and on the simultaneously occurring physical, chemical and biological activities within the landfill (Monroe, 2001). Heavy metals such as lead, mercury, chromium, copper and cadmium, together with household chemicals and poisons can be concentrated in groundwater supplies beneath landfills (Wagner and Rhyner, 1984). These contaminants have been reported to possibly cause growth retardation and haematological abnormalities (Hogson, 2004).

In Lagos, Nigeria exists a typical landfill located in Ojota area (Detail of location described elsewhere (Adeyemi et al., 2007)). The landfill is not lined and receives both hazardous and non-hazardous wastes without prior consideration for their highly polluting effect on the surrounding groundwater. Residential houses with groundwater (Wells and Boreholes) as only source of water were constructed at about 1.5km radius to the landfill. These groundwater sources are continually being consumed by home owners without the knowledge of the possible hazardous effect which the landfill leachate can have on the water quality and public health. Reports presented at seminars and conferences also attested to the prevalence of water related diseases in the inhabitants (LAWMA, 2000). The present study, therefore, examines the effect of such leachate-contaminated groundwater on the growth and blood of rats.

MATERIALS AND METHODS

Chemicals and solvents are of analytical grade and are products of Sigma-Aldrich, inc., St. Louis, U.S.A. The experimental water for the study was collected from the residential areas located within the vicinity of Odo Iya Alaro landfill in Ojota, Lagos, Nigeria. The water samples were obtained from two different wells located at about 1 and 1.5km respectively from the landfill; and two boreholes located at about 1 and 1.5km respectively from the landfill. The water samples were collected using stainless steel buckets.

Solid wastes were collected at the Odo Iya Alaro landfill located in Ojota, Lagos, Nigeria in December, 2004. Leachate simulation was carried out following the ASTM method (Perket et al, 1982). In this method a sample (0.3kg) of the landfill waste was shredded and packed in a 2l glass flask. A volume of distilled water, four times the sample weight, was added. The resulting sample obtained was thoroughly mixed and allowed to stand for 48 hours at room temperature (25 ^{o} C). Continuous stirring was done manually at regular intervals of 2 hours. After 48 hours, the solid and the liquid portions were filtered and the pH of the filtrate was determined. The filtrate which represents the simulated leachate was thereafter stored at 4 ^{o} C. Physicochemical characteristics of the water samples used in this study had earlier been reported (Adeyemi et al., 2007).

Sixty (60) Albino rats (Rattus novergicus) were obtained from the Animal Holding of the Department of Biochemistry University of Ilorin, Ilorin, Nigeria. These rats were fed ad libitum with commercial feeds obtained from Livinco feeds, Jubilee road, Ikare Akoko, Ondo State, Nigeria. The experimental animals were kept inside a wooden cage assigned into six (6) groups of ten (10) animals each. The first two groups of rats were placed on tap water and simulated leachate samples respectively. The third and fourth groups were placed on water samples obtained from wells located at a distance of about 1km and 1.5km respectively from Odo Iya Alaro landfill. The remaining two groups of rats were placed on water samples obtained from boreholes located at a distance of about 1km and 1.5km respectively from the landfill. The last four groups are called the leachate-contaminated groundwater group. The feeding exercise lasted over a period of 65days, a long term standard for rats (Radi et al, 1987), proceeded by 10days acclimatization period.

At the end of the 65days the rats were sacrificed by anaesthetizing in a jar containing cotton wool soaked in diethylether. The jugular veins were cut and blood samples were collected in heparinized tubes preparatory to haematological studies. The samples in the heparinized bottles were gently swirled for proper mixing, and then used for the analyses of PCV, Hb and white blood count (WBC). For the Hb, the cyanomethaemoglobin method of Fairbanks (1982) was used, while the methods of Dacie and Lewis (1991) were used for PCV and WBC. Standard clinical methods described by Khalaf-Allah (1999) was used for platelet, neutrophil and RBC determination.

The one way analysis of variance ANOVA; Duncan's multiple range test (DMRT) was the statistical analysis used. $p<0.05$ was regarded as significance.

RESULTS

The effect of leachate-contaminated groundwater on the body weight of rats placed on it over a period of sixty-five days is presented in Figure 1. Relative to the control, the body weight of rats placed on leachate-contaminated groundwater for sixty-five days is lowered significantly ($P<0.05$). The body weight of the animals placed on simulated leachate was the least among the test groups. Generally, the body weight of the rats as observed in this study was found to be better when the distance of groundwater was about 1.5km from the landfill than when was is about 1km from the landfill. However, the final weight of the animals placed on tap water was significantly ($p<0.05$) higher than those of the animals placed on leachate contaminated-groundwater.

Figure 1

Figure 1: Growth response of rats placed on leachate-contaminated groundwater over a period of sixty-five days. Plotted values are means of ten determinations ± SEM.

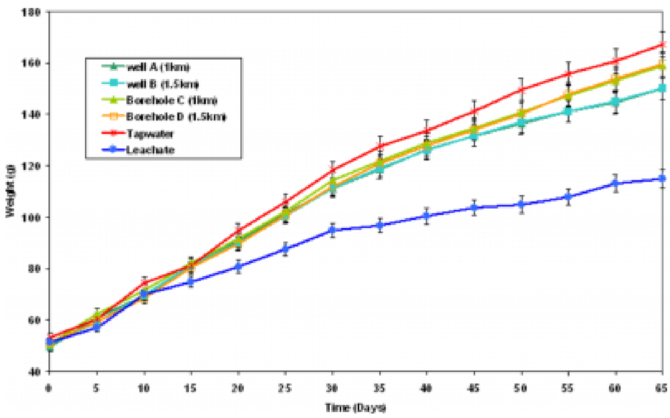

Table 1 presents the feed conversion ratio and daily water intake for rats placed on leachate contaminated-groundwater samples over a period of sixty-five days. No significant ($p>0.05$) difference was observed in the FCR for animals placed on leachate-contaminated groundwater relative to the animals placed on tap water. Similarly, the daily water intake among the experimental animals showed no significant ($p>0.05$) difference. The ratios of the weights of the liver and kidney to body weight for animals placed on leachate-contaminated groundwater are presented in Table 2. The ratios of the weights of the liver and the kidney to body weight of rats showed no significant difference from that of the control ($P>0.05$). In contrast, the weights of the liver and kidney to body weight of rats placed on leachate over a period of sixty-five days were found to be significantly lower than those of control (P<0.05).

Figure 2

Table 1: Feed conversion ratio (FCR) and daily water intake of rats placed on leachate-contaminated groundwater over a period of 65 days.

Group	FCR (g/g)	Daily water intake (ml) Ten rats
Tapwater	0.06 ± 0.01^{a}	585 ± 13^{a}
Leachate	0.05 ± 0.01^{a}	573 ± 15^{a}
Well (1km)	0.05 ± 0.01^{a}	581 ± 10^{a}
Well (1.5km)	0.06 ± 0.01^{a}	577 ± 12^{a}
Borehole (1km)	0.05 ± 0.01^{a}	582 ± 13^{a}
Borehole (1.5km)	0.06 ± 0.01^{a}	584 ± 11^{a}

Tabulated results are means of 10 determinations ± SEM. Values in the same column carrying different superscripts are significantly different (p<0.05).

Figure 3

Table 2: Organ-bodyweight ratio for rats placed on leachate-contaminated groundwater over a period of 65days.

Group	Liver/body wt. (%)	Kidney/body wt. (%)
Tapwater	4.7 ± 0.5^{a}	0.921 ± 0.02^{a}
Leachate	3.2 ± 0.2^{b}	0.681 ± 0.01^{b}
Well (1km)	4.2 ± 0.3^{a}	0.898 ± 0.04^{a}
Well (1.5km)	4.3 ± 0.2^{a}	0.9 ± 0.04^{a}
Borehole (1km)	4.4 ± 0.4^{a}	0.91 ± 0.03^{a}
Borehole (1.5km)	4.5 ± 0.3^{a}	0.913 ± 0.02^{a}

Tabulated results are means of 10 determinations ± SEM. Values carrying different notations are significantly different (p<0.05).

Table 3 shows the concentration of some haematological parameters of rats placed on leachate-contaminated groundwater over a period of 65 days. The Hb levels of animals placed on leachate and leachate-contaminated groundwater were significantly (P<0.05) lower than those of animals on daily consumption of tap water. Similarly, animals placed on leachate showed significantly (P<0.05) lower Hb levels than the rats placed on leachate-contaminated groundwater. The PCV levels of animals placed on leachate and the two leachate-contaminated well water samples were significantly (P<0.05) lower than those of animals placed on tap water. Similarly, animals placed on leachate showed significantly (P<0.05) lower PCV levels than the rats placed on leachate-contaminated groundwater. However, there was no significant (P>0.05) difference between the PCV level of animals placed on the two borehole water samples and that of the control animals. The RBC levels of blood of the animals placed on leachate and leachate-contaminated groundwater were significantly (P<0.05) lower than those of animals placed on tapwater. Similarly, animals placed on leachate showed significantly (P<0.05) lower RBC levels than the rats placed on leachate-contaminated groundwater. The neutrophil concentrations of blood of the animals placed on leachate and leachate-contaminated groundwater samples were found to be higher than those of control rats. Particularly, the neutrophil level of blood of the rats placed on simulated leachate was observed to be about two folds that of the rats placed on tapwater. The WBC counts of the animals placed on leachate and leachate-contaminated groundwater samples were observed to be significantly (P<0.05) higher than those of control rats, it was about two folds that of rats on tapwater. Platelet concentrations of blood of the animals placed on leachate and leachate-contaminated groundwater samples were found to be significantly higher than those of control rats except that platelet concentrations of blood of the animals placed on the two borehole water samples showed no significant (P<0.05) difference from that of the control.

Figure 4

Table 3: Haematological parameters of rats on daily consumption of leachate – contaminated groundwater for 65days.

Parameters	Group					
	Control	Leachate	Well (1km)	Well (1.5km)	Borehole (1km)	Borehole (1.5km)
PCV (%)	40 ± 2^{a}	26 ± 4^{b}	33 ± 2^{c}	35 ± 1^{c}	36 ± 2^{a}	38 ± 1^{a}
Neutrophil (%)	14 ± 1.2^{a}	32 ± 3^{b}	28 ± 2^{b}	22 ± 2^{c}	19 ± 1^{c}	16 ± 1^{d}
WBC(/l)x 10^{9}	5.3 ± 0.1^{a}	10.2 ± 0.2^{b}	7.4 ± 0.4^{c}	7.1 ± 0.2^{c}	6.6 ± 0.1^{d}	6.2 ± 0.2^{a}
Platelet(/l)x10^{9}	561 ± 9^{a}	600 ± 11^{b}	596 ± 6^{b}	581 ± 10^{b}	574 ± 9^{a}	570 ± 7^{a}
RBC(/l) x 10^{2}	7.6 ± 0.1^{a}	5.9 ± 0.2^{b}	6.4 ± 0.4^{c}	6.4 ± 0.2^{c}	6.9 ± 0.4^{d}	7.0 ± 0.1^{a}
Hb (g/dl)	14.3 ± 0.3^{a}	10.9 ± 0.2^{b}	11.9 ± 0.2^{c}	11.9 ± 0.2^{c}	12.6 ± 0.4^{d}	13.9 ± 0.2^{f}

Tabulated results are means of 10 determinations ± SEM. Values in the same row carrying different superscripts are significantly different (p<0.05).

DISCUSSION

The observation on body weight (Figure 1) may be associated with the high concentrations of pollutants in the leachate-contaminated groundwater samples which may make utilization of the nutrients inefficient or chelating the nutrients that should have been available for use by the rats. Dolk (1999) reported stunted growth in children who consume leachate-contaminated water containing materials like Cd, Pb, and high levels of organics evidenced by high BOD level.

The daily water intake and FCR as observed (Table 1) in this study showed that all experimental rats eat and drink normally irrespective of the source of water. The observed organ:body weight ratio of experimental rats (Table 2) revealed that, within the period of the experiment, the concentrations of pollutants in the leachate- contaminated groundwater samples may not have affected the liver-body weight and kidney-body weight ratios of the animals in those groups. However, the concentrations of pollutants in the leachate may be responsible for the lower liver-body weight and kidney-body weight ratios observed in the animals in the group. This may be because the levels of pollutants in leachate are several times higher than the safe level for drinking water. The leachate was found to contain heavy metals such as Pb, Cd, Cr, etc. which have the potential to produce undesirable effects on tissues, in particular, the kidney and liver. As manifested in this study Radi et al (1987) reported that health hazards caused by consumption of leachate are usually manifested faster and are more pronounced than those caused by the consumption of leachate-contaminated groundwater.

The relatively lower haemoglobin, PCV and RBC concentrations of the blood of experimental rats (Table 3) observed in this study suggest that the pollutants of the leachate-contaminated groundwater can directly or indirectly or both destroy RBCs and lower the haemoglobin concentration. The direct effect may be as a result of the presence of bacteria in the leachate which may cause diseases such as typhoid fever, dysentery and so on that can eventually lead to lysis of RBC. The indirect effect may be as a result of oxidative damage, amongst others, to tissues thereby releasing MDA which had been reported to be able to destroy RBCs and reduce erythrocyte survival (Hadley and Draper, 1988). Islam et al, (2004) reported that changes in haematological parameters such as Hb, PCV and RBC are routinely used to determine stress associated with environmental, nutritional and / or pathological factors. Conditions such as lower concentration of RBC and Hb have been associated with anaemia (Islam et al, 2004) which have in turn been related to the health effects of consuming leachate-contaminated groundwater (Fred and Jones-Lee, 1994). Studies are underway to be able to ascertain the form of anaemia associated with the consumption of leachate-contaminated groundwater.

Additionally, the increase in concentration of neutrophil and WBC in blood of the rats placed on leachate-contaminated groundwater samples may also be as a result of nutritional and / or pathological factors arising from ingestion of leachate-contaminated groundwater. The nutritional factors may be due to the presence of hazardous chemicals in the groundwater samples while the pathological factor may arise from the bacteria present in the leachate-contaminated groundwater. Oladiji et al. (2004) had also reported that factors such as environmental, nutritional and pathological can elevate concentrations of WBC and neutrophil in the blood.

Increased platelet concentration observed in the blood of rats placed on leachate-contaminated well water samples may be attributed to the presence of heavy metals, amongst others, in the leachate-contaminated well water samples. Platelet or thrombocytes are the blood cell fragments that lead to the formation of blood clots. High levels of platelets, although usually asymptomatic, may arise from ingestion of high levels of Pb (Datta et al, 1994).

The following summarizes the major conclusion from this study;

- Ingestion of the leachate-contaminated groundwater resulted in reduced the growth response of rats.
- The consumption of the leachate-contaminated groundwater resulted in abnormal haematological changes such as low Hb, PCV and RBC which portend anaemia
- The consumption of the leachate-contaminated groundwater resulted in elevated level of neutrophils and platelet which are indicative of ill health and thrombosis

From the foregoing the authors therefore advise that the Agencies involved in setting standards for drinking water should not rely on routine chemical analysis of water alone but go further to examine the haematological parameters highlighted in this study before water is certified safe for drinking.

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