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Full Length Research Paper

The use of Lichens in the biomonitoring of heavy metal concentrations in Nnamdi Azikiwe University premises

***Umeh, S.O.[1], Agu, G.C.[2], Okpalla, J[3]. and Uche, E.O.[1]**

[1]Department of Applied Microbiology and Brewing, Nnamdi Azikiwe University,Awka, Nigeria.

[2]Department of Microbiology Olabisi Onabanjo University, Ago-Iwoye, Ogun State. Nigeria

[3]Department of Microbiology, Anambra State University, Uli, Anambra State Nigeria.

***Corresponding Author**'s email: sophina.umeh@yahoo.com

Abstract

Heavy metals accumulation in the environment can cause dangerous ailments such as cancer, respiratory disorders, skin diseases etc to man. This work was carried out to monitor the concentrations of seven heavy metals (lead, zinc, cadmium, copper, chromium, mercury and arsenic) in four locations at Nnamdi Azikiwe University, Awka premises, using lichen as a bio-monitor. The locations were: Garba square (A), Science Village (B), Administrative Block (C) and Faculty of Environmental Sciences [Bakasi] (D). Results obtained were compared with WHO Standard (E) after analysis with (ANOVA) using SPSS computer Software (version 20) at 0.05 significant levels. It was observed that the concentrations of lead were high in C and D (0.83 and 1.25 ppm respectively) higher than E (0.50 ppm). Zinc was accumulating in three locations with B (5.87 ppm) showing the highest. The concentrations of Chromium in C and D were (0.103 ppm and 0.228 ppm respectively). Copper was increasing in all the locations, but below the standard. Cadmium in A was higher than the standard (1.17 and 0.80 ppm respectively). Mercury was not detected in any of the locations while arsenic was high in A and B (63.37 and 35.50 ppm respectively) surpassing the standard (1.00 ppm). It was advised that the sources of these metals be checked to avoid the bad effects they may cause in future.

Key words: Heavy metals, lichen, bio-marker, Unizik, environment, pollution

INTRODUCTION

Living things including plants and animals are exposed to a wide spectrum of atmospheric pollutants, which pose serious threat to health especially the *homo sapiens* (Humans). These pollutants are being released from industries, exhaust of motor vehicle, machineries, and other anthropogenic activities. These pollutants have led to diseases such as cancer, mutation, headache, respiratory and lung diseases (Prajapati *et al*. 2006; Prajapati and Tripathi, 2007). Heavy metals are classified among the most potent groups of anthropogenic environmental pollutants due to their toxicity and persistence in the environment (Ackah *et al*. 2011; Sayadi and

Sayyed, 2011; Sayyed and Wagh, 2011; Tiwari, 2011; Anim *et al*. 2012; Prajapati *et al*. 2006). The degree and extent of environmental changes over the last decades has given a new urgency and relevance to the detection and understanding of environmental change, due to human activities, which have altered global biogeochemical cycling of heavy metals and other pollutants. There are approximately 5 million chemicals presently known, 80,000 are in use; 500 - 1,000 are added per year resulting in a progressive increase in the flux of available chemical forms to the atmosphere (Akosy, 2008). Air pollution has been one of the major threats to human health and the environment since the last century (Akosy, 2008; Berlizov *et al*., 2007). The World Health Organization (WHO) estimates that more than 2 million premature deaths occur annually, worldwide, and these can be attributed to the effects of outdoor and indoor air and land pollution (WHO, 2002).

Most of these pollutants occur in minute concentrations that vary considerably in space and time; they are difficult to measure. There is proper need for humans to constantly monitor her environment to ensure that the air which is being inhaled is good enough for healthy survival. It will go a long way in eradicating and reducing the proliferation of detrimental effects caused by pollutants released in the environment. The atmospheric condition of the environment can be controlled and monitored using bio-monitors.

Many plants have been reported to capture trace elements in the environment and can be used as bio-monitors (Rhoades, 1999; Rossini and Rautio, 2004; Madejón *et al*. 2006; Prajapati *et al*. 2006; Prajapati and Tripathi, 2007). Higher plants function as bio-monitors of aerial metal contamination due to their accumulation properties. Lichens are the most studied bio indicators of air quality (Fernandez *et al*, 2006). They are conspicuous, grey, green, orange, or red patches on trees or rocks (Dragovič, and Mihailovič, 2009). They are formed by the symbiotic association of a fungus and algae. In this association, the alga functions as the part that is occupied with the formation of nutrients since it contains chlorophyll, while the fungus supplies the algae with water and minerals. These organisms are perennial and maintain a uniform morphology over time. They grow slowly; have a large-scale dependence upon the environment for their nutrition, and differently from vascular plants. They do not shed parts during growth (Dragovič and Mihailovič, 2009).

Lichens have been defined as "permanent control systems" for air pollution assessment (Cenci *et al.,* 2003). As a result of their high sensitivity towards specific pollutants and ability to store contaminants in their biological tissues, lichens are defined as indicators and / or bio accumulators of pollutants (Cenci *et al.,* 2003,). In this study, they are used to monitor the concentrations of some selected heavy metals in Nnamdi Azikiwe University premises. This will help in the evaluation of heavy metal load of the environment and at the same time investigate the possibility of using these bio-indicators to clean the environment.

The aim of this work therefore was to check the presence of these metals in the University environment, determine their concentrations as absorbed by the lichens and advise on the use of lichens for the clean up. This will help to check the deleterious effects that may arise in future.

MATERIALS AND METHODS

Study area:

Four locations in the University Community were selected namely: Garba square (A), Science Village (B), Administrative Block (C) and Faculty of Environmental Sciences

[Bakasi] (D). These areas were selected because they are the oldest sites in the University community. Concentrations of seven heavy metals (lead, zinc, chromium, copper, cadmium, mercury and arsenic) were monitored in the environment.

Collection of samples

Lichen species (Foliose) were collected from the various sampling areas and were identified in the Botany Department of the University. The Lichens were collected by gently scrapping them off from the bark of the trees where they grew. Care was taken not to include the tree bark. The lichens were air dried for 3 weeks and ground using a sterile Corona manual blender. The blended samples were stored in an air-tight container and taken to Spring Board Laboratory, Awka, for analysis

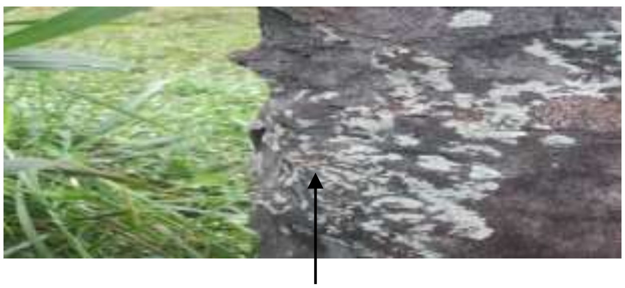


Plate 1: Lichens on a Palm Tree.

Sample Analysis

Sample Digestion: The method of Adrian as reported by Al-Shayeb *et al*. (1995) was used to digest the ground dried lichen samples. Two grams of each sample was added into a digestion flask. Twenty milliliters of acid mixture containing 650ml conc. HNO_3, 8ml perchloric acid, 20 ml conc. H_2SO_4 were added into the flask. The mixture was heated until a clear digest was obtained. The digest was diluted with distilled water to 100 ml mark.

Methods of Heavy Metal Analysis Using Atomic Absorption Spectrophotometer

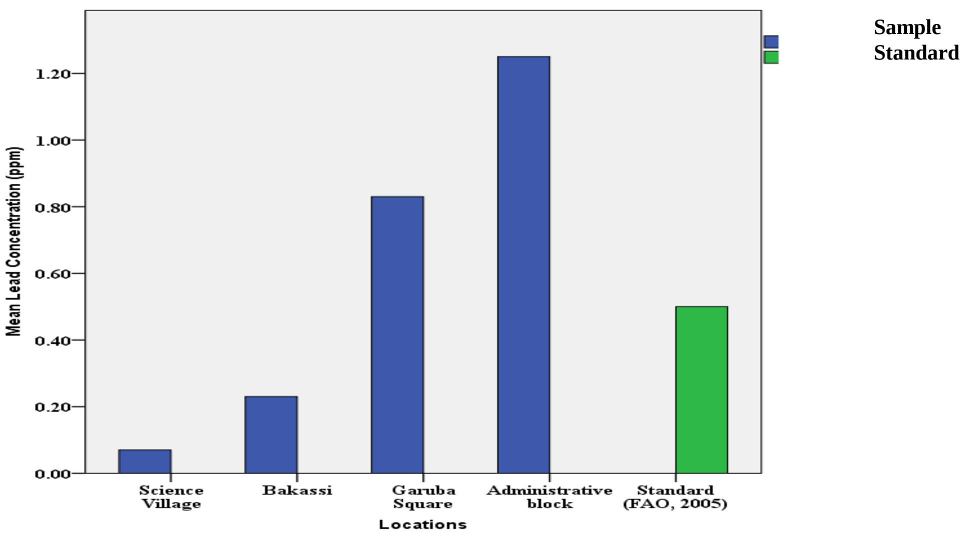
Atomic Absorption Spectrophotometer method of APHA (American Public Health Association) as described by Fernandez *et al.* (2006) was used. The sample was thoroughly mixed by shaking and 100ml of it was transferred into a glass beaker of 250ml volume, to which 5ml of conc. nitric acid was added and heated to boil till the volume is reduced to about 15-20ml, by adding conc. nitric acid in increments of 5ml till all the residue is completely dissolved. The mixture was cooled, transferred and made up to 100ml using metal free distilled water. The sample was aspirated into the oxidizing air-acetylene flame. When the aqueous sample was aspirated, the sensitivity for 1% absorption was observed.

Data Collection and Statistical Analysis

Data generated from the studies were subjected to analysis of variance (ANOVA) using SPSS computer Software package (version 20) at 0.05 significant levels.

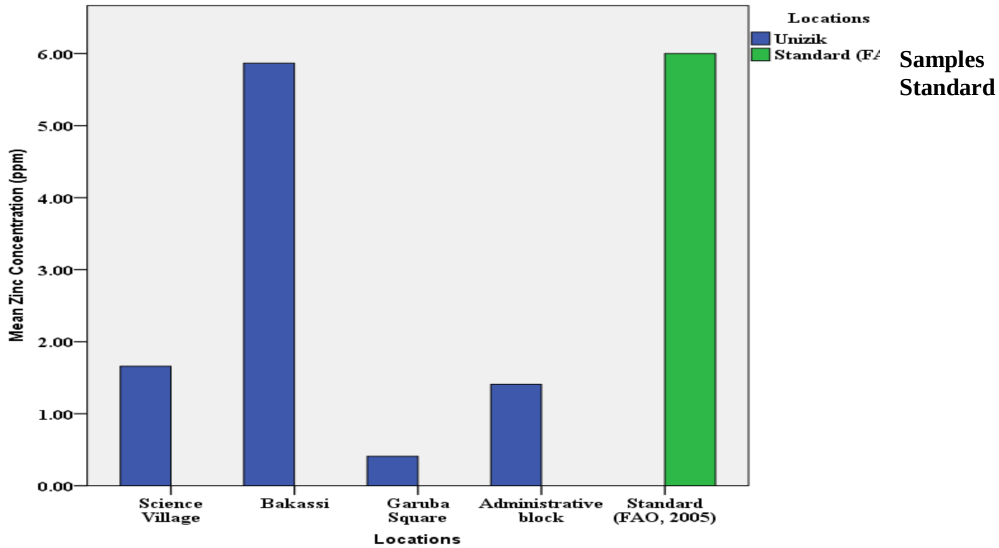
RESULTS

Results obtained from the research were compared with the standards stipulated by the World Health Organization (WHO, 2002). The results showed that the concentration of lead was high in locations C and D (0.83 and 1.25 ppm respectively). Their concentrations in these areas were high compared with E (0.50 ppm), the standard (Fig 1). Zinc, chromium and copper concentration of E were higher than that of the various locations as shown in Figs 2, 3 and 4. But the concentration of zinc in B (5.87 ppm) was accumulating to surpass the standard while chromium concentrations were increasing in C and D (0.103 ppm and 0.228 ppm respectively). Copper concentrations in all the locations were increasing as shown in Fig 4. The concentration of cadmium in A was higher than the standard (1.17 and 0.80 ppm respectively) as seen in Fig 5. No trace of mercury was detected in all the locations studied while arsenic concentrations in A and B were higher than the standard (63.37 and 35.50 ppm respectively) surpassing the standard (1.00 ppm) as presented in Fig 6.



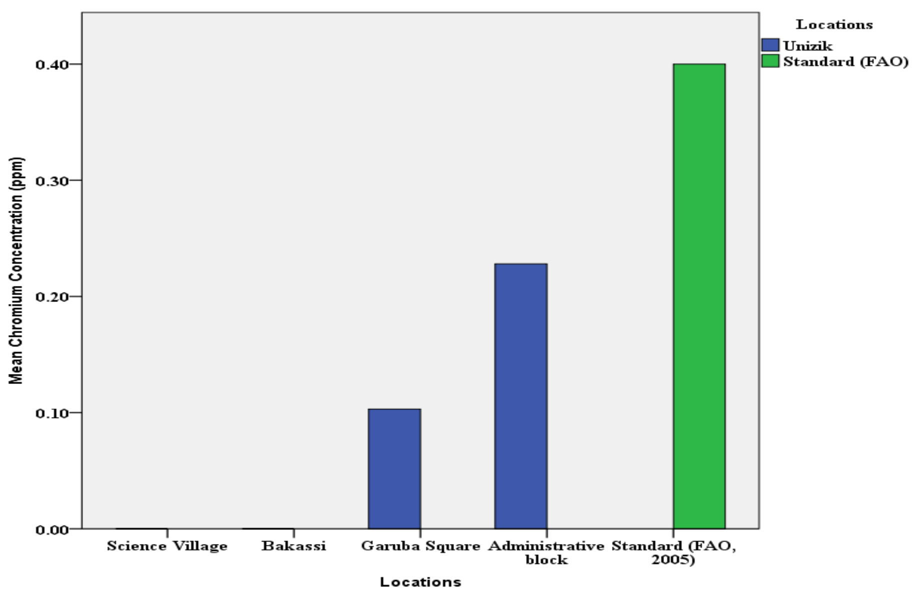
A B C D E

Figure 1: Lead concentrations in the four locations and the WH0 standard.



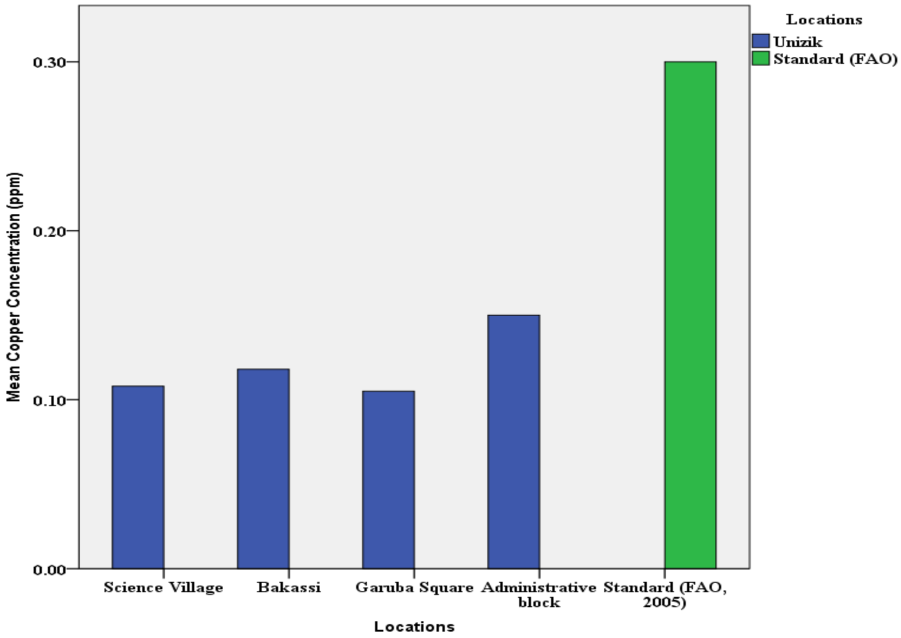
A B C D E

Figure 2: Zinc concentrations in the four locations and the WH0 standard.



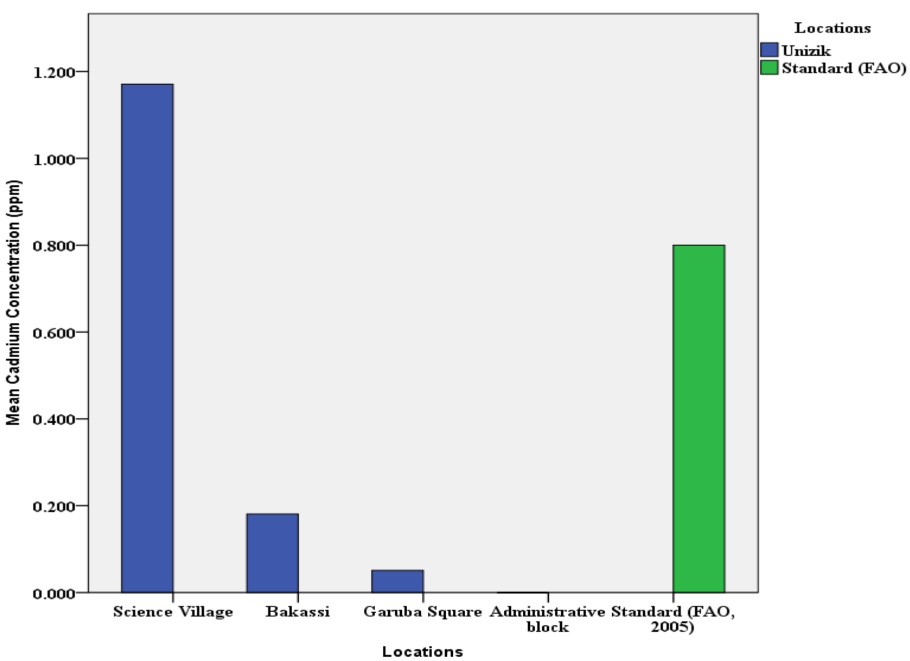
A B C D E

Figure 3: Chromium concentrations in the four locations and the WH0 standard.



A B C D E

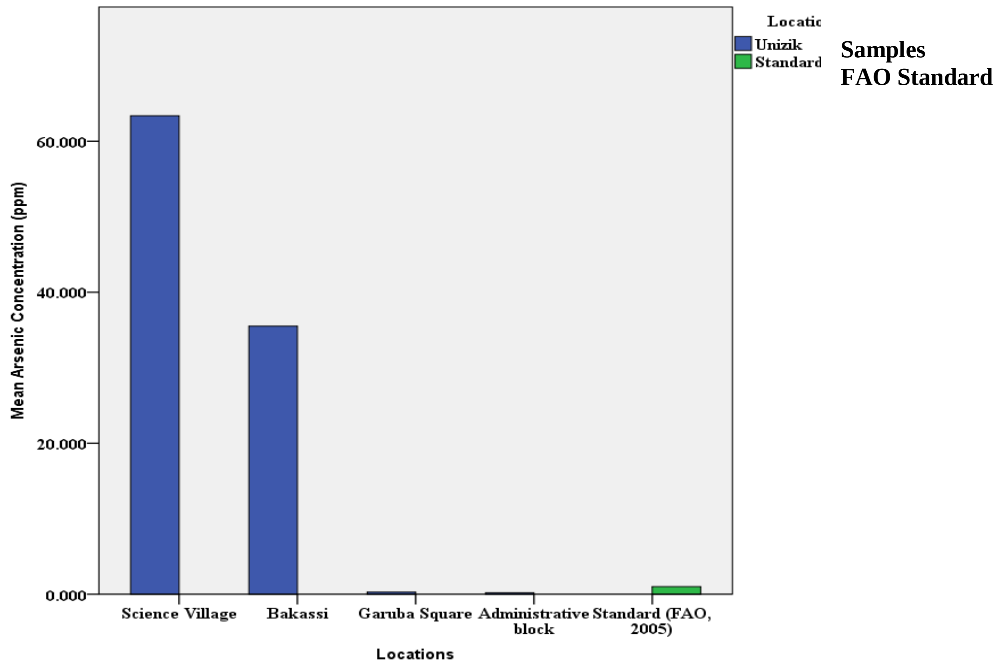
Figure 4: Copper concentrations in the four locations and the WH0 standard



Samples
Standard

A B C D E

Figure 5: Cadmium concentrations in the four locations and the WH0 standard.



Locations

A B C D E

Figure 6: Arsenic concentrations in the four locations and the WH0 standard.

DISCUSSION

Various activities were carried out in different locations of the University premises, ranging from farming, photocopying, use of generator sets, automobiles etc. These activities contribute in one way or the other in the release and accumulation of some heavy metals in the environment. It is important to regularly monitor the environment to check the presence of these pollutants and quickly remedy them to avoid the health hazards that can arise from them.

The results obtained from the different sites studied were supposed to be influenced by the activities carried out in that site. The analysis of the heavy metals found in Lichen samples indicated the variable values for the different locations sampled as indicated in the bar charts (Fig 1 - 6). Fig 1 showed that lead concentration was high in C and D when compared to other locations and the standard (P >0.05). This implies that the concentration of lead might be detrimental to the lives in those environments. The causes and sources of the high concentration of lead need to be identified so as to help check its accumulation in the life of humans and animals found in the area. Some of the activities carried out there have to be checked. Efforts should be made to have constant electricity supply in the Administrative block building to reduce drastically the effect of the power house.

Also, the entrance of other heavy duty vehicles and the use of machines which has the tendency of releasing lead have to be properly controlled. The administrative block is one of the busiest places in the school. It's likely that the smoke released from the exhaust of cars, generators and other machines might as well be releasing lead in the environment which results to this high concentration in the environment. The school bus stand is situated at Garba square, with many other activities such as use of generators, photocopiers and other equipment that can contribute in the release of lead in the environment.

Fig 2 showed that the concentration of Zinc is high in B (5.8679 ppm) when compared to other locations. It was seen to be approaching the standard. The mean zinc concentration is significant at this site but not significant in other locations ($p > 0.05$). This implies that zinc accumulation may not impose treat in the environment now, but latter it will reach threshold and its effect will be felt in the environment. There is therefore an urgent need to check the cause and introduce the method of remediation fast. For in a short while it may affect the lives in the environment when not controlled.

Fig 3 showed that the concentration of chromium was high in C (0.103 ppm) and D (0.228 ppm) when compared to other locations, though not up to E (0.400 ppm). However the mean concentration was not significant when compared with the standard ($p > 0.05$). The International Agency for Research on Cancer (IARC) (1993) showed that high concentration of chromium can cause cancer, gastrointestinal disorders, haemorrhagic diathesis, convulsion, mutation and death. There is great need to check the activities carried out in these two areas so as to prevent the accumulation and its negative effect.

Copper concentrations in the four sites were increasing as seen in Fig 4. It was highest in D (0.15 ppm). When compared with the standard, the mean copper concentration from the study was not significant. Increase in copper in the environment can be caused by some natural and anthropogenic activities such as decaying vegetation, forest fires, spray, iron foundries, plant stations and combustion sources such as municipal incinerators (Walkers *et al*., 2001). Efforts should be made to check the causes of the accumulation to avoid its negative effects on lives in the environment.

The concentration of cadmium in A (1.171 ppm) was higher than the standard (0.80 ppm) as shown in (Fig 5). When compared with the standard, the mean cadmium concentration in the environment was significant when location A is considered. The high concentration of cadmium in the environment can be a big threat in the environment considering the fact that Cadmium exerts toxic effects on the kidney, the skeletal and the respiratory systems, and is classified as a human carcinogen (IARC 1993; WHO, 2009; Waalkes *et al*., 2001). Hence there is need to check the source and cause of this increment in this environment. Activities that can release cadmium in the environment include natural activities, such as weathering and erosion, human activities like tobacco smoking, use of phosphate fertilizers, and recycling of cadmium-plated steel scrap and electric and electronic wastes (WHO, 2009; Walkers *et al*., 2001). Cadmium released can be carried to and deposited on areas remote from the sources of emission by means of long-range atmospheric transport (Walkers *et al*., 2001).

No trace of mercury was detected in the various locations studied. Arsenic concentration in location A and B are higher (63.4 ppm and 35.5 ppm respectively) than the standard (1.0 ppm) and the other locations (Fig 6). However, when compared with the standard, the mean arsenic concentration in these two locations is significant, but not significant in the other locations. Health effects of arsenic are determined by the dose (how much), the duration (how long), and the route of exposure. Inhalation of inorganic arsenic may cause respiratory irritation, nausea, skin effects, and increased risk of lung cancer. Acute high dose oral exposure to inorganic arsenic may cause nausea, vomiting, diarrhea, cardiovascular effects and encephalopathy. Long term oral exposure to low levels of inorganic arsenic may cause dermal effects (such as hyper pigmentation and hyperkeratosis etc) and peripheral neuropathy characterized by numbness in the hands and feet that may progress to a painful "pins and needles" sensation. There may also be an increased risk of skin cancer, bladder cancer, and lung cancer (ATSDR, 2007).

Conclusion and Recommendation

Unmonitored environment is in darkness and such environment lays oblivion to the major cause of disease transferred via atmospheric pollution. In conclusion, this study revealed that some heavy metals were accumulating in the sites studied. There is need to monitor the probable cause of the increment and the use of lichens in the environmental clean-up. When these heavy metals are not controlled they accumulate in the body and often result in deadly diseases like cancer and death.

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