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CONCENTRATIONS OF FORMALDEHYDE IN RAIN WATERS HARVESTED AT THE NIGERIAN INSTITUTE FOR OIL PALM RESEARCH

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ABSTRACT

Formaldehyde has been recognized as one of the most important pollutants and a carcinogen that is present in the air, water, foods, soils, fabrics, cosmetics, cigarette smoke and treated wood. Related health effects and hazards are linked to formaldehyde, depending on mode of exposure which includes: weakness, blindness, vomiting et cetera. Additionally, occupational exposure through vapours, results in a temporary reversible decrease in lung function. Ocular exposure to formaldehyde could result in permanent alterations to vision or blindness. At concentrations below maternal toxicity, formaldehyde is considered not to be a reproductive or developmental toxicant. Sufficient evidence is now available for the carcinogenicity of formaldehyde in both humans and animals. The International Agency for Research on Cancer has classed formaldehyde as a group 1carcinogen. Rain water is harvested and used for domestic and industrial purposes in Nigeria. Scarce information is available in the developing countries like Nigeria, relating to the sources of exposure to formaldehyde and other toxic substances. It was against the above background that samples of rain water were collected between April and October, 2008, 2009 and 2010 at the meteorological research unit of the Nigerian Institute for Oil Palm Research (NIFOR) in order to monitor the concentrations of formaldehyde, which were subsequently consumed by ingestion and thus generate data on same for the populace of the area of study. The chromotropic acid method described by the National Institute for Occupational Safety and Health (NIOSH) was adopted for the determination of formaldehyde in the rain waters. Results indicated that the concentration range of the formaldehyde in the rain waters varied from month to month throughout the six months duration of analysis. The values detected were below the toxicity level recommended by the World Health Organization (WHO) and other world bodies for drinking water. In conclusion, the results of the rain waters collected for the period of assay suggests that the values did not cause any toxicity effects and thus were fit for human consumption based on the low formaldehyde concentrations.

Key words: Formaldehyde, Rain Water, NIFOR, Toxicity

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INTRODUCTION

Water is one of the most important natural resources, and contains dissolved gases, minerals, organic and inorganic substances. Water in its pure form is colourless, odourless, tasteless and sparkling in nature [1]. Rain water usually contains dissolved gases like oxygen, carbon dioxide, ammonia, formaldehyde et cetera. As rain water containing dissolved gases, particles of dust and smoke runs through the ground into streams, it impacts turbidity, taste and odour. Formaldehyde is easily photo-oxidized to carbon dioxide in the presence of sunlight and reacts relatively fast with trace elements/substances or pollutants in air, thus having a short half –life in an urban environment [2]. Formaldehyde is naturally formed in the troposphere during the oxidation of hydrocarbons. These react with OH radicals and ozone to form formaldehyde and/or other aldehydes as intermediates in a series of reactions that ultimately lead to the formation of carbon monoxide and dioxide, hydrogen, and water. When terpenes and isoprene emitted by foliage react with the OH radicals, formaldehyde is formed as an intermediate product [2]. Arising from their short life-times, this potentially important source of formaldehyde is only important in the vicinity of vegetation [3].

Formaldehyde is the most common aldehyde in the air with natural background concentrations less than1µg/m^3.Rain water has been reported to contain 110 – 174 µg/L with peaks as high as 310 – 1380 µg/L[4].

The concentration of formaldehyde in drinking water is generally about 0.1mg/L resulting in a mean daily intake of 0.2mg/day. The quantity of formaldehyde in food depends on the composition of the meal and, for an average adult, may range from 1.5 to 14mg/day [4].

Male and female Wister rats showed a significant reduction in body weight compared to the controls when exposed to formaldehyde in drinking water. The reduction in body weight resulted from the drop or reduction in food in-take [5].

Based on the genotoxic potentials of formaldehyde as evident from results of both in-vitro and in-vivo studies, formaldehyde is regarded as mutagenic at the site of contact [5].

The carcinogenicity of formaldehyde has been demonstrated in several studies involving rats by inhalation. Additionally, the carcinogenicity of formaldehyde has also been observed in rats exposed to formaldehyde in drinking water [6]. Due to the uncontrolled population increase and ageing of infrastructure at the Nigerian Institute for Oil Palm Research (NIFOR) Benin City, the water treatment scheme, which is serviced by the river Okhuo, can no longer meet the domestic and the palm oil milling requirements. As a result, inhabitants now depend on rain water in addition to the plant treated water. It was against this background that this research was conducted, to monitor the formaldehyde concentrations of the rain waters consumed in 2008, 2009

and 2010. Additionally, the institute is a farm settlement, where yearly bush burning and applications of fertilizers, pesticides, herbicides and vehicular movements that may contain some levels of formaldehyde may interact with the rain waters. It is, therefore, hoped that the data generated would be useful to the inhabitants of the institute as a nutritional guide.

MATERIALS AND METHODS

Sample Collection

This study was focused on the rain waters at the Nigerian Institute for Oil Palm Research, Benin City. Thus, the rain water samples were collected once a week in duplicate bottles of 250 ml at the meteorological research unit of the Nigerian Institute for Oil Palm Research (NIFOR) in Benin City, between April and October, 2008, 2009 and 2010. Daily collections of samples of rain water were not possible because rain did not fall on a daily basis. The average results for duplicate samples as above were obtained per week and a further average obtained per month as reported in Table 1. The materials used for the research were well washed and rinsed with deionized water and allowed to dry in an air oven made by Gallenkap. As soon as the waters were collected they were sent to the laboratory for immediate formaldehyde concentration determination throughout the period of collections.

Determination of formaldehyde in rain water

The chromotropic acid method was adopted for the analysis of formaldehyde in the rain waters [7].

Statistical Analysis

Mean ± SD for the parameters measured were compared for statistical differences using Student's t-Test and the BBSSTA package.

RESULTS

The results obtained are presented in Table 1 and Fig.1. The formaldehyde concentrations detected in the rain waters varied from month to month throughout the period of sampling. The comparison of the month by month analysis indicated that the month of September 2009 had the lowest concentration relative to the same month in 2008 and 2010. On the other hand, the month of June 2010 had the highest concentrations of formaldehyde in the rain waters harvested. Overall, the statistical analysis indicated that significant differences existed between the concentrations of each month (though low) but could be significant in its cumulative concentrations that might result in some characteristic side effects of formaldehyde on the long run. (Fig. 1 gives a clearer picture of the observable differences).

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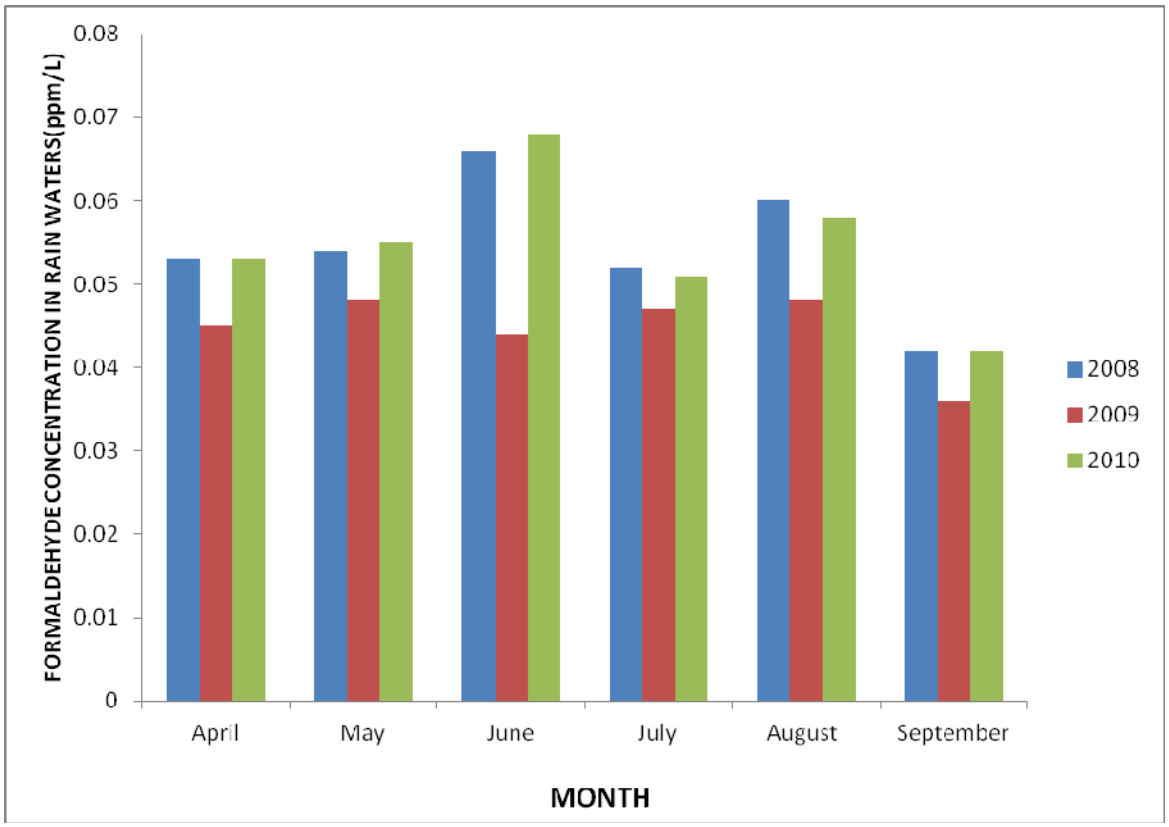

Figure 1: Formaldehyde concentrations in rain waters harvested in NIFOR: month-by-month comparison (2008 – 2010)

DISCUSSION

Numerous factors might be responsible for the low levels of formaldehyde detected in the rain waters under reference. In the atmosphere, formaldehyde is not only absorbed during the formation of cloud droplets but its ease of solubility/hydration may result in the formation of methylene glycol and its oligomers, which might be a contributory factor to the low levels of formaldehyde detected in the rain waters [8, 9].The World Health Organization had reported that formaldehyde is considered to be highly soluble in water, and its Henry's Law constant (3 X 10^{-5}KPam^3/mol) suggests that it will be unlikely to volatilize from water [10]. Reports have indicated that the concentrations of formaldehyde in rain water at a remote site in the Central Equatorial Pacific ranged from 0.31 to 1.38 mg/L [10]. In other words, the above values of formaldehyde in rain waters may not be so toxic as to be able to cause any mutagenic effects at the site of contact, and / or cause any reproductive or developmental toxicity [8].

Rain waters collected were used for both domestic and drinking purposes. Experimental reports have indicated that ingested formaldehyde is readily absorbed by the gastro-intestinal tract and is rapidly oxidized to formic acid, with subsequent oxidation to carbon dioxide and water [8]. The formation of metabolic products associated with urea and formate have been reported in rats and monkeys [12, 11]. Metabolites are eliminated in the urine, faeces, and expired air, in relative amounts depending on the route of administration [8]. There is little evidence that formaldehyde is carcinogenic by oral route if exposed to mild concentrations, since the substance is readily absorbed and metabolized by the gastrointestinal tract of the humans [13].Besides, there is some evidence that formaldehyde is a carcinogen in humans exposed by inhalation [13]. Following the experiments in which the humans and animals were exposed to chronic formaldehyde by inhalation, formaldehyde was classified in Group 1 (Carcinogenic to humans) [14].

From toxicological evidence, the levels of the concentrations of the formaldehyde detected in the rain waters might be too low to cause any effects in humans. However, studies have revealed useful evidences about the consequences of ingestion of chronic amounts of formaldehyde in man [14].

Overall, researchers have shown that the toxicological effects of the ingestion of formaldehyde depend on the level of concentration and time of exposure [14].

The concentrations of formaldehyde detected in the rain waters under reference can be considered negligible (below 0.1mg/day) and therefore of no effect.

CONCLUSION

The concentration of formaldehyde detected in the rain waters were low and thus pose no harmful effects on the inhabitants of the area. All values detected were lower than the standard toxicity levels recommended by the World Health Organization and other recognized international bodies as capable of causing toxicological effects or disorders in humans. Further research is underway to determine and generate data for formaldehyde in harvested rain waters in other parts of the country, in addition to consumables /cosmetic products which contains formaldehyde as preservative, to serve as health guide for the populace.

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Table 1: Formaldehyde concentrations in rain waters harvested at the Nigerian Institute for Oil Palm Research

MONTH /YEAR	FORMALDEHYDE CONCENTRATION IN RAIN WATERS(ppm/L)				
	Week1(Mean)	**Week2(Mean)**	**Week3(Mean)**	**Week4(Mean)**	**Mean (ppm/L)**
APR					
2008	0.091±0.001	0.002±0.000	0.079±0.001	0.038±0.001	0.053±0.000
2009	0.090±0.000	0.001±0.000	0.078±0.000	0.030±0.000	0.045±0.001
2010	0.092±0.002	0.002±0.000	0.078±0.000	0.039±0.000	0.053 ±0.000
MAY					
2008	0.040±0.010	0.030±0.000	0.045±0.000	0.099±0.000	0.054±0.001
2009	0.041±0.000	0.029±0.001	0.048±0.001	0.090±0.000	0.048±0.000
2010	0.042±0.000	0.030±0.000	0.051±0.000	0.098±0.001	0.055±0.000
JUN					
2008	0.009±0.002	0.090±0.000	0.090±0.000	0.075±0.002	0.066±0.002
2009	0.008±0.001	0.090±0.000	0.090±0.000	0.079±0.000	0.044±0.001
2010	0.009±0.002	0.092±0.001	0.092±0.001	0.080±0.000	0.068±0.000
JUL					
2008	0.090±0.000	0.007±0.000	0.080±0.001	0.030±0.001	0.052±0.002
2009	0.089±0.001	0.009±0.000	0.083±0.000	0.007±0.001	0.047±0.002
2010	0.092±0.000	0.008±0.001	0.079±0.000	0.026±0.000	0.051±0.000
AUG					
2008	0.030±0.001	0.030±0.001	0.090±0.000	0.090±0.000	0.060±0.001

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2009	0.030±0.001	0.028±0.000	0.080±0.002	0.080±0.001	0.048±0.000
2010	0.028±0.000	0.031±0.001	0.085±0.001	0.087±0.000	0.058±0.002
SEPT					
2008	0.001±0.000	0.070±0.000	0.085±0.000	0.010±0.000	0.042±0.001
2009	0.003±0.001	0.065±0.002	0.078±0.002	0.009±0,000	0.036±0.002
2010	0.002±0.000	0.071±0.001	0.083±0.002	0.012±0.000	0.042±0.001

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