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Research Article

Organochlorine Pesticides (Aldrin, DDT) and PCBs in Market Available Cigarettes in Abeokuta, Ogun State, and Their Health Risks

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Abstract

Cigarette smoking, or tobacco consumption, remains a significant health concern around the world. While there has been more focus on the harmful effects of nicotine in cigarettes, only little is known about some other components such as Polychlorinated biphenyls and organochlorine pesticides like DDT and Aldrin, which are used on tobacco farms. Human exposure to pesticide residues on tobacco occurs when residues remaining in cigarette smoke are inhaled.

This study was carried out with the aim of (i) investigating the concentration levels of organochlorine pesticides (Aldrin and DDT) and PCB in ten Market available cigarettes in Abeokuta, Ogun State, and (ii) assess the human health associated with the concentration levels found in the cigarettes.

The Mean concentration ranges of the pesticides in the cigarette samples were as follows; Aldrin (0.015µg/g - 0.048µg/g). DDT (0,116µg/g - 0.330µg/g), and PCB (0.223µg/g - 0.567µg/g). From the analysis, the hazard quotient for the pesticides and PCB were also very low and unable to cause any health problems, with the cancer risk in them also at a very minimal level. However, PCB is more likely to be carcinogenic due to its high cancer risk values, though it might not have a significant effect in contributing to non-carcinogenic adverse effects, just like with DDT and Aldrin.

Keywords: DDT; Aldrin; Polychlorinated Biphenyls; Cigarettes; Human Health; Cancer.

INTRODUCTION

Pesticides are any substance or mixture of substances of chemical or biological ingredients intended for repelling, destroying, or controlling any pest, or for regulating plant growth [1]. Pesticides and agrochemicals, in general, became an important component of worldwide agriculture systems during the last century, allowing for a noticeable increase in crop yields and food production [2].

Use of plant protection chemicals, mainly pesticides, has become integral part of modern agricultural production systems around the world, not only to protect the crop but also to secure the optimum crop yield [3]. Organochlorine pesticides (also called chlorinated hydrocarbons) are organic compounds attached to five or more than five chlorine atoms. They represent one of the first categories of pesticides ever synthesized and are used in agriculture [4].

In 1972, over twelve thousand tons of pesticides were used on tobacco crops, and according to a study to determine the chlorinated pesticide residue levels in mainstream smoke, the rate of transfer of pesticides from tobacco into smoke averaged about 12% of that in the tobacco before combustion [5]

Pesticide residue can remain on tobacco leaves after harvesting and processing them into their manufactured forms. When tobacco is smoked, these residues, along with the tobacco and other additives, are burnt, and the resultant smoky mixture inhaled by active and passive smokers is known as pyrolysis products [5].

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Effects of Pesticides on Humans

The characteristics of pesticides, such as high lipophilicity, bioaccumulation, long half-life and potential of long-range transport, have increased the chances of contaminating the air, water and soil, even after many years of application [6]. Due to lack of proper legislation, improper market regulations and ignorance shown by people, agricultural workers from developing countries are prone to experience high levels of agricultural chemicals, including pesticides [7]. Among agriculturalists of developing countries, pesticide exposure is the primary occupational hazard, which leads to health issues and environmental contamination associated with pesticide use [8-12]. Organochlorine pesticides may alter the proper function of the nervous system of the insects leading to disorders such as convulsions and paralysis followed by eventual death [13].

Aldrin

Aldrin is a colorless organochlorine insecticide spread to soils to kill termites, grasshoppers, corn rootworm, and other insect pests. It is highly lipophilic and its solubility in water is only 0.027 mg/L, which intensifies its persistence in the environment [14]. Aldrin is a synthetic organochlorine pesticide that is used as a broad-spectrum soil insecticide for protection of food crops, and as seed dressing for the control of pests such as ants and termites [15]. Aldrin exposure among the general population may result via dietary intake, however over time, it has become harder to find aldrin residue in food. Neurotoxic symptoms in humans include headache, dizziness, general malaise, muscular twitching, vomiting, or myoclonic jerks after prolonged exposure to lower dosages of these substances [15].

Dichlorodiphenyltrichloroethane (Ddt)

In 1940s, DDT was used as the first modern synthetic insecticide to control insect in agriculture, housing, institutes and to combat insect-

borne human diseases [16]. Although DDT use has generally been restricted since the early 1970s, exposure to the pesticide remains widespread [17]. Until present, there is no substitute for DDT in terms of comparable efficiency and operational possibility on vector-borne diseases control [18]. DDT was classified into class II (moderate toxic) in the WHO classification system for pesticides [19]. DDT exposure can occur by eating, breathing, or touching products contaminated with DDT [20]. Following exposure to high doses, human symptoms can include vomiting, tremors or shakiness, and seizures. Laboratory animal studies show DDT exposure can affect the liver and reproduction. DDT is a possible human carcinogen according to U.S. and International authorities [17].

Polychlorinated Biphenyls (Pcbs)

PCBs were first produced commercially in the 1920s, although it was not until the 1950s that the industrial application of PCBs increased significantly [21]. PCBs build up throughout the food chain. They spread to and concentrate in the liver and fat tissue after being quickly absorbed from the digestive system [22]. PCB exposure, especially during fetal and early life, reduces IQ and alters behavior. The PCBs alter thyroid and reproductive function in both males and females and increase the risk of developing cardiovascular and liver disease and diabetes. Women are at high risk of giving birth to infants of low birth weight, who are at high lifetime risk for several diseases [23].

Pesticides in Cigarettes

Manufacturers have described the cigarette as "a drug administration system for the delivery of nicotine in acceptable and attractive form" [24]. Smokers are exposed to a toxic mix of over 7,000 chemicals when they inhale cigarette smoke. The harmful chemicals in cigarette smoke can damage nearly every organ in the body. Nonsmokers are exposed to many of these same chemicals through secondhand smoke [25]. Pesticides sprayed on tobacco plantations are among the over 5,000 chemicals that can be found in tobacco products [3,26,27]. When tobacco is smoked, these residues can be degraded but usually not destroyed. Due to the huge number of toxic chemicals, the presence of pesticides in tobacco products and smoke is not treated as an additional alarming issue [5]. The wide range of pesticides used on tobacco crops includes Dichlorodiphenyltrichloroethane (DDT) and lindane, two organochlorine compounds whose use is today limited due to their toxic effects on both environment and human health [28]. DDT also belongs to the 98 tobacco smoke components for which risk assessment authorities have established a human inhalation risk value for cancer [29].

MATERIALS AND METHODS

Sample Collection

The cigarette samples were collected at Osiele Market in Abeokuta, and transported to the Environmental Management and Toxicology Laboratory at the Federal University of Agriculture, Abeokuta, Ogun State, Nigeria. The samples include 10 different brands of cigarettes popular in Nigeria.

Sample Preparation

Each cigarette wrap was torn to remove the tobacco content for easier access to take samples for weighing. The dried tobacco samples were then wrapped in a white sheet of paper, after which small portions were gradually taken for weighing.

Sample Extraction

Exactly 2.0g of each tobacco sample was weighed twice into separate centrifuge tubes to serve as duplicate samples. In each centrifuge tube containing the weighed tobacco sample, 4ml of Formic acid was added to facilitate digestion. The tube was then placed in a water bath for 30 minutes at 90C and allowed to cool at room temperature. Thereafter, approximately 4ml of hexane was added, after which it was shaken for 5 minutes and centrifuged at 4000 revolutions per minute for 3 minutes. After centrifugation, two layers were obtained, comprising of the top and bottom layers. The top hexane layer was transferred into a clean sample vial using a teat pipette. Another 4ml of hexane was subsequently added to the centrifuge tube containing the residue, and extraction was repeated, followed by the subsequent transfer of the top hexane layer into the same sample vial. The extraction was repeated for a third time by adding 4 ml of ethanol into the centrifuge tube containing the residue, after which it was centrifuged. The top layer obtained is subsequently transferred into the sample vial used for extract collection.

Pesticide Analysis

Samples were analyzed by the use of a model PAS-1701 gas chromatograph (Agilent, GC Model 68900) equipped with a fused capillary column of (30m length × 0.32mm i.d. and 0.25-µm film thickness). Oven temperatures were programmed from an initial temperature of 160°C for 1 min, ramped to 260°C at a rate of 5°C/min, and then held at 260°C for 15 min. Nitrogen was then used as the carrier gas at a flow rate of 3mL/min. Residues were detected using an Electron Capture Detector (ECD).

Data Analysis

Organochlorine pesticide data were subjected to simple descriptive (mean and standard deviation) and inferential (Duncan Multiple Range Test) statistics using SPSS for Windows (version 22.0).

Health risk assessment

The health risk assessment of OCPs was calculated for Average Daily Dose (ADD), Hazard Quotient (HQ), Hazard Index (HI), and Cancer Risk (CR), using the formula highlighted by USEPA.

$$\mathrm{ADDing} = \frac{C \times \mathrm{IRing} \times EF \times ED}{BW \times AT} \quad (1)$$

Where, ADD = Average daily dose (mg kg^{-1} day^{-1})

C = Concentration of OCPs in cigarette (mg kg^{-1}),

IRing = Ingestion rate of cigarette (50 mg day^{-1}),

IRinh = Inhalation rate of cigarette (20 m^{-3} day^{-1}),

ED = Exposure duration (years) = 30 years for carcinogenic effects for adults,

EF = Exposure frequency (day/year) = 365 days $year^{-1}$,

CF = Conversion factor = 10^{-6} kg mg^{-1} (4.2 x 10^{-2})

PEF = Particle emission factor = 1.36 x 10^{9} m^{3} kg^{-1}

AT = Averaging time or life expectancy = 54.5 years, AT = ED for non-carcinogenic effects,

BW = Body weight (kg); 60 kg for an adult.

$$\mathrm{HI} = \sum_{i=1}^{n} HQ \qquad i=1...n \quad (2)$$

$$\mathrm{HI} = \sum_{i=1}^{n} HQ \quad (3)$$

Where, ADD =Average daily dose (mg kg^{-1} day^{-1}),

RfD =Reference dose (mg kg^{-1} day^{-1}),

N=numbers of observed elements.

HQ > 1 denotes adverse health effects; HQ < 1 indicates no adverse

effects,

Cancer Risk = ADD x SF (4)

Where, ADD = Average daily intake (mg kg^{-1} day^{-1}),

SF = Slope factor (mg^{-1} kg day)

RESULTS AND DISCUSSION

The Mean Concentrations of Selected Organochlorine Pesticides; Aldrin, Dichlorodiphenyltrichloroethane (DDT), and Polychlorinated Biphenyls (PCBs) in cigarette samples from Osiele market in Abeokuta are shown in Table 2. The mean concentration of Aldrin ranges between 0.048 ± 0.001 µg/g and 0.015 ± 0.001 µg/g, DDT ranges between 0.330 ± 0.002 µg/g and 0.116 ± 0.002 µg/g, and PCB ranges between 0.567 ± 0.001 µg/g and 0.223 ± 0.001 µg/g.

Tables 3 and 4 also show the Hazard Quotient and Cancer risk of each organochlorine pesticide as determined for each brand.

Table 1: Names of the 10 selected cigarette brands

NAMES OF SELECTED CIGARETTE BRANDS	
1	Rothmans Menthol
2	Time
3	B&H Switch
4	Bohem
5	Royal Standard
6	Edge Change
7	Edge
8	Pall Mall
9	Rothmans
10	B&H Special Filter

DISCUSSION

Analysis of the mean concentration, as shown in Table 2, shows that the pesticide residue Aldrin has the lowest concentration of pesticides in the cigarettes. The brand with the highest concentration of Aldrin is Pall Mall, with a concentration of 0.048 µg/g, which varies widely from the concentration found in Rothmans Menthol, 0.015 µg/g, having the lowest concentration of Aldrin. The analysis also shows that PCB has the highest overall concentration of Pesticides. The cigarette brand, Pall Mall, has the highest concentration of 0.567 µg/g compared to the Time, which has the lowest PCB concentration with 0.223 µg/g. For DDT, overall concentration is just below that of PCB, and the result shows that Pall Mall has the highest concentration, 0.330 µg/g, while Edge has the lowest concentration, 0.116 µg/g.

Table 3 shows the analysis of the hazard quotient for all the pesticides in each cigarette brand. For Aldrin, Pall Mall has the highest hazard quotient at 0.00132, while Rothmans Menthol has the lowest at 0.00042. For DDT, Pall Mall recorded the highest value at 0.00055, while Edge recorded the lowest at 0.00019. For PCB, Pall Mall was determined to have the highest hazard quotient with 0.0263, compared to the value for the cigarette brand, Time, which has the lowest value of 0.00929. However, since a hazard quotient less than or equal to 1 indicates that adverse effects are not likely to occur and can be considered negligible, this means that the possibility for non-cancer health hazards to occur is extremely unlikely in all the selected cigarettes because they all have a hazard quotient less than one.

Figure 1, which shows the Hazard Index, also indicates that the cumulative values of all the hazard quotients will still be very unlikely to cause any problems as they all sum up to less than one. However, from Figure 2, which shows the contribution of these pesticides and PCB to non-carcinogenic adverse effects, PCB is more likely to pose a risk than Aldrin and DDT, both of which remain highly unlikely to cause any adverse effects.

Table 4 also shows cancer risk values of Aldrin, DDT, and PCB in the selected cigarettes. Since the risk of cancer due to exposure to a contaminant is commonly expressed in exponential terms of between 10^{-6} and 10^{-4} (USEPA, 2018), it can be seen that values for Aldrin and DDT are not within this range. However, for PCB, certain brands, such as B&H Switch, Bohem, Royal Standard, Edge Change, Edge, Rothmans, and B&H Special Filter, all fall within the possible risk range. Since they all have values ranging between 1.1 x 10^{-6} and 1.5 x 10^{-6}, this means that the likelihood of cancer caused by PCB is one in 1,000,000, with other values not within this range having no possible risk factor.

Figure 3 shows the sum of cancer risk values, still indicating a low possibility of causing cancer. As also shown in Figure 4, PCB was determined to be more likely to cause cancer compared to the levels of Aldrin and DDT.

CONCLUSION AND RECOMMENDATIONS

The above study shows the likelihood of organochlorine pesticides and PCB posing a potential risk factor in cigarettes. In the brands of cigarettes selected for this study, Polychlorinated Biphenyls (PCB) were present in greater amounts than seen for DDT and Aldrin, with Pall Mall being the brand with the highest amount of organochlorine pesticides and PCB.

In general, the study also shows that there is no significant amount of organochlorine pesticide that can cause serious health problems in the selected brands. However, PCB is more likely to be carcinogenic due to its high cancer risk values, though it might not have a significant effect in contributing to non-carcinogenic adverse effects, just like with DDT and Aldrin.

Controlling pesticide use when growing Tobacco is absolutely essential due to the negative effects these pesticides could potentially have on human health. Regular education and awareness campaigns on the risks of PCB exposure due to tobacco use or cigarette smoking should be conducted.

Additionally, the government should strongly oppose the import of pesticides. Also, to be avoided is soil that has been exposed to these chemicals. Pests should be managed using biological, cultural, and other less dangerous pest management techniques.

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Table 2: Descriptive statistics of OCPs (µg/g) and PCB (µg/g) in cigarette

µg/g		N	Mean	Std. Deviation	Minimum	Maximum
Aldrin	Rothmans Menthol	2	0.015a	0.001	0.014	0.016
	Time	2	0.020bc	0.001	0.019	0.021
	B&H Switch	2	0.037g	0.001	0.036	0.037
	Bohem	2	0.026d	0.003	0.024	0.028
	Royal Standard	2	0.018ab	0.001	0.017	0.019
	Edge Change	2	0.024bc	0.002	0.022	0.025
	Edge	2	0.034fg	0.001	0.033	0.035
	Pall Mall	2	0.048h	0.001	0.047	0.048
	Rothmans	2	0.033f	0.002	0.031	0.034
	B&H Special Filter	2	0.028e	0.001	0.027	0.029
	Total	20	0.028	0.01	0.014	0.048
DDT	Rothmans Menthol	2	0.206f	0.002	0.204	0.207
	Time	2	0.177d	0.002	0.175	0.178
	B&H Switch	2	0.219g	0.001	0.218	0.22
	Bohem	2	0.155b	0.001	0.154	0.155
	Royal Standard	2	0.225h	0.001	0.224	0.226
	Edge Change	2	0.298i	0.004	0.295	0.3
	Edge	2	0.116a	0.002	0.114	0.117
	Pall Mall	2	0.330j	0.002	0.328	0.331
	Rothmans	2	0.196e	0.003	0.194	0.198
	B&H Special Filter	2	0.168c	0.004	0.165	0.17
	Total	20	0.209	0.063	0.114	0.331
PCB	Rothmans Menthol	2	0.249b	0.004	0.246	0.251
	Time	2	0.223a	0.001	0.222	0.224
	B&H Switch	2	0.318d	0.001	0.317	0.319
	Bohem	2	0.443h	0.005	0.439	0.446
	Royal Standard	2	0.353f	0.005	0.349	0.356
	Edge Change	2	0.313d	0.003	0.311	0.315
	Edge	2	0.289c	0.004	0.286	0.292
	Pall Mall	2	0.567i	0.001	0.566	0.568
	Rothmans	2	0.338e	0.001	0.337	0.339
	B&H Special Filter	2	0.403g	0.003	0.401	0.405
	Total	20	0.349	0.098	0.222	0.568

Table 3: Hazard quotient values of OCPs and PCB in cigarette

		Mean	Std. Deviation	Minimum	Maximum
Aldrin	Rothmans Menthol	0.00042	0.00004	0.00039	0.00044
	Time	0.00056	0.00004	0.00053	0.00058
	B&H Switch	0.00101	0.00002	0.001	0.00103
	Bohem	0.00072	0.00008	0.00067	0.00078
	Royal Standard	0.0005	0.00004	0.00047	0.00053
	Edge Change	0.00065	0.00006	0.00061	0.00069
	Edge	0.00094	0.00004	0.00092	0.00097
	Pall Mall	0.00132	0.00002	0.00131	0.00133
	Rothmans	0.0009	0.00006	0.00086	0.00094
	B&H Special Filter	0.00078	0.00004	0.00075	0.00081
DDT	Rothmans Menthol	0.00034	0	0.00034	0.00035
	Time	0.00029	0	0.00029	0.0003
	B&H Switch	0.00037	0	0.00036	0.00037
	Bohem	0.00026	0	0.00026	0.00026
	Royal Standard	0.00038	0	0.00037	0.00038
	Edge Change	0.0005	0.00001	0.00049	0.0005
	Edge	0.00019	0	0.00019	0.0002
	Pall Mall	0.00055	0	0.00055	0.00055
	Rothmans	0.00033	0	0.00032	0.00033
	B&H Special Filter	0.00028	0.00001	0.00028	0.00028
PCB	Rothmans Menthol	0.01035	0.00015	0.01025	0.01046
	Time	0.00929	0.00006	0.00925	0.00933
	B&H Switch	0.01325	0.00006	0.01321	0.01329
	Bohem	0.01844	0.00021	0.01829	0.01858
	Royal Standard	0.01469	0.00021	0.01454	0.01483
	Edge Change	0.01304	0.00012	0.01296	0.01313
	Edge	0.01204	0.00018	0.01192	0.01217
	Pall Mall	0.02363	0.00006	0.02358	0.02367
	Rothmans	0.01408	0.00006	0.01404	0.01413
	B&H Special Filter	0.016792	0.000118	0.016708	0.016875

Table 4: Cancer risk values of OCPs and PCB in cigarette

		Mean	Std. Deviation	Minimum	Maximum
Aldrin	Rothmans Menthol	0.00042	0.00004	0.00039	0.00044
	Time	0.00056	0.00004	0.00053	0.00058
	B&H Switch	0.00101	0.00002	0.001	0.00103
	Bohem	0.00072	0.00008	0.00067	0.00078
	Royal Standard	0.0005	0.00004	0.00047	0.00053
	Edge Change	0.00065	0.00006	0.00061	0.00069
	Edge	0.00094	0.00004	0.00092	0.00097
	Pall Mall	0.00132	0.00002	0.00131	0.00133
	Rothmans	0.0009	0.00006	0.00086	0.00094
	B&H Special Filter	0.00078	0.00004	0.00075	0.00081
DDT	Rothmans Menthol	0.00034	0	0.00034	0.00035
	Time	0.00029	0	0.00029	0.0003
	B&H Switch	0.00037	0	0.00036	0.00037
	Bohem	0.00026	0	0.00026	0.00026
	Royal Standard	0.00038	0	0.00037	0.00038
	Edge Change	0.0005	0.00001	0.00049	0.0005
	Edge	0.00019	0	0.00019	0.0002
	Pall Mall	0.00055	0	0.00055	0.00055
	Rothmans	0.00033	0	0.00032	0.00033
	B&H Special Filter	0.00028	0.00001	0.00028	0.00028
PCB	Rothmans Menthol	0.01035	0.00015	0.01025	0.01046
	Time	0.00929	0.00006	0.00925	0.00933
	B&H Switch	0.01325	0.00006	0.01321	0.01329
	Bohem	0.01844	0.00021	0.01829	0.01858
	Royal Standard	0.01469	0.00021	0.01454	0.01483
	Edge Change	0.01304	0.00012	0.01296	0.01313
	Edge	0.01204	0.00018	0.01192	0.01217
	Pall Mall	0.02363	0.00006	0.02358	0.02367
	Rothmans	0.01408	0.00006	0.01404	0.01413
	B&H Special Filter	0.016792	0.000118	0.016708	0.016875

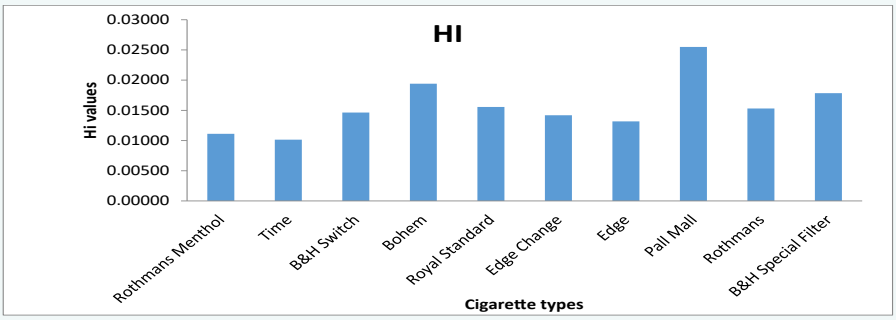

Figure 1: Hazard index values of OCPs and PCB in cigarettes

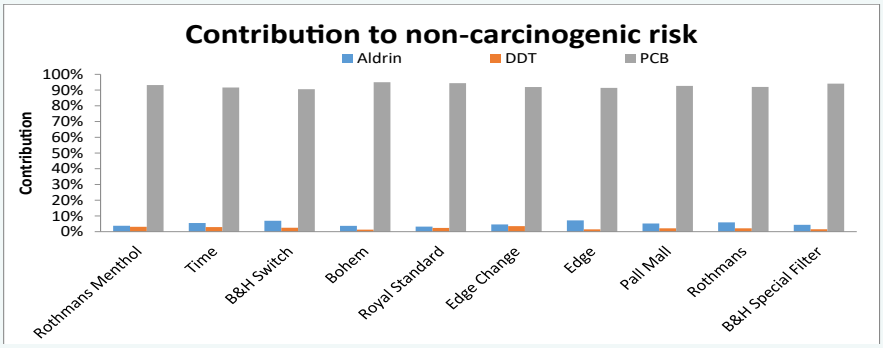

Figure 2: Contribution of OCPs and PCB to non-carcinogenic adverse effects

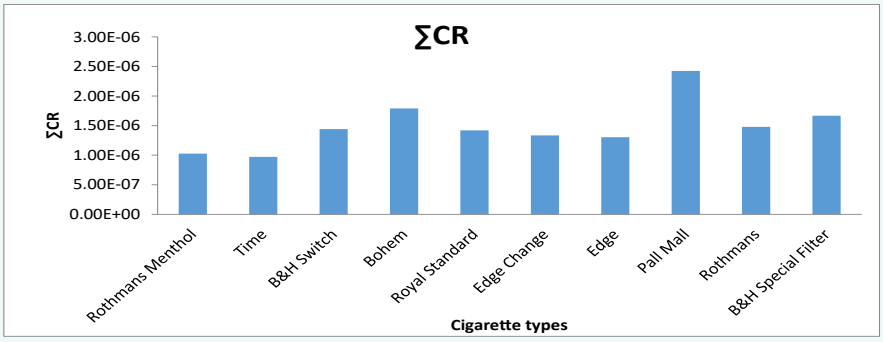

Figure 3: Sum of cancer risk values of OCPs and PCB in cigarette

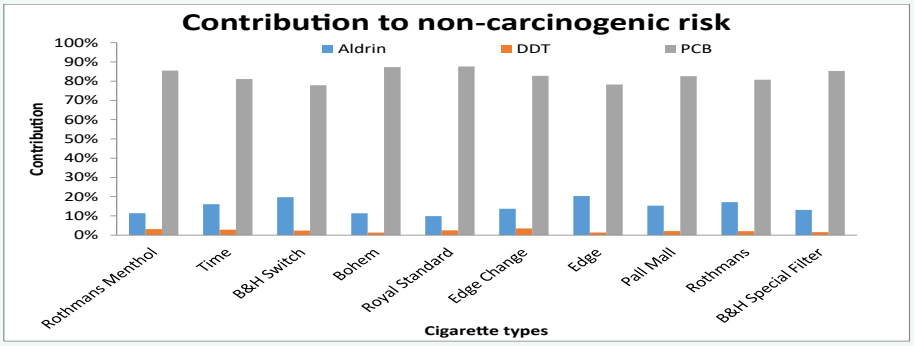

Figure 3: Sum of cancer risk values of OCPs and PCB in cigarette

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