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A REVIEW OF TOXIC EFFECTS OF PETROLEUM PRODUCTS

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ABSTRACT

Gasoline or petrol is the most common fuel used for vehicles. Petroleum vapours are present in high concentrations around petrol pumps and are harmful in nature. The present review compiles the studies done in various parts of world on the deleterious effects of petroleum products.The available studies suggest that petroleum products are nephrotoxic and hepatoxic. No conclusive studies are available to support the role of petroleum products in skin, respiratory,reproductive and neuropsychiatric disorders.

KEYWORDS: *Petrol, vapour, oxygen species, anaemia, hypertension*

INTRODUCTION

Petrol consists of hydrocarbons (aromatic, saturated and unsaturated) and non-hydrocarbons (N, S, O_2, vanadium and nickel).It is volatile and easily combustible and used as fuel for majority of machines[1,2]. The petrol contains low boiling point hydrocarbons so it can be easily converted to vapour and inhalation is the most common form of exposure.[3] Petrol fumes can be extremely dangerous in closed or poorly ventilated areas, although such exposures are rare.[4]

The intentional inhalation of vapour ('sniffing' or 'huffing') has been extensively documented [5] At low concentrations, gasoline causes burning and itching in the the eyes, throat and skin. Exposure to higher concentrations of vapour may cause adverse effects on nervous system such as

strolling gait, slurred speech,blurred vision and disorientation The inhalation in very large quantity may cause unconsciousness and death. [6] Drivers are exposed to petroleum fumes for brief period when they visit petrol pumps for fuelling, but the petroleum workers are exposed for very long period due to their job responsibility.[1] Exposure to these fumes for seconds is also dangerous.The exposure up to 140 ppm for half an hour can be toxic. Vapour concentration is 25,000 ppm in air above open barrel in unventilated out-house on 'hot' day, atmosphere around tanker contains 50 to 320 ppm while air in and around gasoline filling stations during operations contains around 20-200 ppm. [1] [7] It has been demonstrated that after inhalation of petroleum vapour through chronic exposure,unsaturated hydrocarbons are found in higher quantity in human and animal blood than saturated hydrocarbons. Both diesel and gasoline engine exhausts are known to contain, in either the particulate or the vapour phase, a range of mutagenic and carcinogenic agents .[8] Benzene and toluene are major aromatic hydrocarbons present in the refined petrol.The study on the workers exposed to bitumen fumes during road construction demonstrates the presence of 1-hydroxypyrene and thioesters in urine which indicates the exposure of laborers to polycyclic hydrocarbons.[9] Ueng *et al.*(1998) reported that exposure of rats to vehicular exhaust and organic extracts of the exhaust particulate resulted in a rise of a detoxifying enzymes such as *cytochrome P450 dependent monoxygenases* and *glutathione-S-transferase* in the liver, kidney and lung microsomes. Since petrol is source of these exhausts, long or brief exposure to their vapours may affect the antioxidant capacity in exposed individuals.[10]

HEPATOTOXICITY OF PETROLEUM PRODUCTS

Benzene and related hydrocarbons are oxidized by reacting with reactive oxygen species (ROS) forming an intermediate epoxide, which is highly reactive and oxidize liver microsomal proteins and nucleic acids leading to cell damage[11]. Components in petroleum can cause hepatic damage , this ranges from mild damage indicated by increased enzymes to severe damage leading to hepatic failure, These can also cause neurological damage, anaemia, hypertension, impotence, sterility and miscarriage.[12] The impact of toxins is usually determined biochemically by the monitoring of some plasma enzymes and lipids. A rise in enzymes such as *aspartate aminotransferase (AST), alanine aminotransferase (ALT), alkaline phosphatase (ALP*), and cholesterol are indicators for liver cells damage.[13] Petroleum hydrocarbons are converted to ROS in liver and kidney cells.It is these ROS which causes lipid peroxidation of membranes leading to its damage.[14] They oxidixe protein leading to enzyme inactivation. [15] and or DNA breakage of the strands [16]. An increase levels in these enzymes activities in the plasma are linked to hepatocellular damage caused by either toxins, toxins in drugs or herbs [17]. The study was conducted to assess the level exposure to this product and the possible damage caused to the liver among petrol hawkers and petrol pump workers in Maiduguri metropolis in Nigeria..There is a significant rise in the levels of cellular hepatic enzymes such as *aspartate aminotransferase, alanine aminotransferase* and alkaline *phosphatase* in petrol hawkers when compared with normal subjects. [18 .Duricic *et al*,1991 reported that there are degenerative changes in liver and kidney functions in rats exposed to petrol [19], it is also in agreement with the studies of Dede and Kagbo:2001 who reported a dose dependent hepatocytes necrosis in rat fed in diesel fuel contaminated source.[20]

Shibatam reported that increase in size of the liver,growth depression and histological changes were observed in rats fed with DDT and PCB contaminated diets. [21], in the investigation with petrol filling station workers in Owerri,Nigeria,There is significant rise in the concentration of enzymes indicating hepatocellular damage of the attendants working for more than six years as compared to normal subjects.There is insignificant difference in the values of total,direct and indirect bilirubin for petrol pump workers and the normal subjects.[22] Petrol hawkers were found to have significantly low albumin concentration in comparison to normal subjects.[18]

Sunmonu and Oloyode observed that major drop in serum protein concentration (albumin and globulin)was found in a study conducted on rats which were on diet of catfish contaminated with crude oil.[23]

NEPHROTOXICITY OF PETROLEUM PRODUCTS

In a study conducted on Petrol Station attendants in Owerri Nigeria, the proteinuria was observed in petrol pump attendants working for more than 6 years whereas protein was absent in urine of control group and and the group exposed to fuel vapour from 1 – 5 years. Parameters indicating renal damage i.e., seum urea and serum creatinine was significantly increased in group of attendants working for more than six years as compared to group of persons working in petrol pumps between 1 to 5 years and group who is not exposed to petrol products. [22]

Artimaeus and Jacobs (2003) observed kidney damage in motor mechanics exposed to gasoline vapours during their job [24].The exposure in low quantity of Alberta crude oil (ACO) to rats several times do not change any biochemical parameters indicating systemic impairment [25]. A study on workers exposed to hydrocarbons demonstrated that

petroleum products damage kidney leading to proteinuira and excretion of enzymes such as *LDH* and *N-acetyl -ß- glucosaminidase* [26]. The study conducted at sulaimani city on gasline filling workers demonstrated that long term exposure to petrol fumes is damaging to kidney and decreases the concentration of immunoglobulins which indicates immunotoxicity.[27] Petroleum exposure was found to initiate inflammatory response indicated by increased IgM levels in petrol attendants of Nigeria.[28] The plasma protein profile is considerably changed on long term exposure to petrol fumes due to pathological changes in kidney and liver.[29] Rats exposed to petroleum related products components demonstrates nephrotoxicity. [30] Both human and experimental studies suggest that many chemicals present in petroleum can be nephotoxic.[31] Studies have shown that exposure to petrol derivatives may have detrimental effects on kidney functions.[32],[33 .Stengel *et al.*, reported that petroleum products are responsible for ESRD, but no evidence is available it causes glomerulonephritis.[34],Jacob *et al.*, showed that working with petroleum fumes results in chronic liver diseases such as membranous glomerulonephritis and ESRD.[35] Increase concentration of gasoline fumes in working area directly effect workers causing several occupational hazards including kidney diseases [36]

OXIDATITIVE DAMAGE DUE TO PETROL PRODUCTS

Xenobiotics within the organism undergo chain of reactions and biotransformation to facilitate their excretion. Oxyradicals are regularly generated in eukaryotes during regular oxidatitive processes in the cells.Certain compounds such as metals, hydrocabons and nitro derivtives and quinols increase the generation of ROS.The production of oxidatitive species can also be increased by conditions of hypoxia/hyperoxia and cytochrome P450 system.[37] Consequently, aerobic organisms have evolved antioxidant system The antioxidant system consist of non enzymatic antioxidants such as ascorbic acid, tocopherols,glutathione and carotenoid, and specific antioxidant enzymes such as *catalase*, SOD, *glutathione peroxidase and glutathione reductase*.[38]The results of study conducted at petroleum attendants at Nigeria high level of oxidatitve stress in these subjects when compared with the normal subjects. [39]. Environmental toxic-ants and gasolone vapours increase the peroxidation of biomolecules inside the cells [40]. Oxidatitive stress results into peroxidation of lipids in the membranes forming malondialdehyde (MDA). This oxidative stress may have resulted from the build-up of such as $O_2^-$and H_2O_2 following the decrease in the activities of the enzymatic antioxidants. The increased generation of $O_2^-$and H_2O_2 leads to increase production of the more reactive hydroxyl (OH.) radicals via Fenton and Haber-Weiss reactions [41]. OH.Radicals can oxidize any molecule of the cell react including lipids, DNA and proteins[41]. The overall outcome of this process leads to extensive changes in DNA stricture, mutation and loss of activity of enxymes. [42]

The enhanced lipid peroxidation and deceased antioxidant capacity was observed in the gaoline filling attendants when compared with normal subjects.Reduced antioxidant capacity is evident from the significant decrease in the enzymatic antioxidants-*superoxide dismutase (SOD)* and *catalase (CAT)*-as well as the non-enzymatic redox sensitive thiol compound, reduced glutathione (GSH). *SOD* and *CAT* enzymes are major primary antioxidant defense components that primarily catalyze the dimutation of superoxide radical (O_2^-) to H_2O_2 and decomposition of H_2O_2 to H_2O, respectively [43,44]. The decreased *SOD* and *CAT* concentration induced by exposure to petroleum fumes probably results in accumulation of $O_2^-$and H_2O_2 which react with metal ions to promote additional radical generation, with release of the particularly reactive hydroxyl radicals (OH^-). [41] OH^- reacts reacts with all the major components of cell leading to extensive cell damage [45].The oxidatitive species leads to cell damage resulting in inflammation. [46].The concentration of glutatione decreases with increase in oxidatitive stress indicated by increase in TBARS. [47,48] Decreased glutathione weakens the cell defense against the toxic action of xenobiotic which could lead to cell injury or death. [49] Decreased glutathione indicates that subjects is under oxidatitive stress due to high exposure of environmental pollutants.[50] Vitamin E is a powerful chain-breaking antioxidant, primarily inhibiting lipid peroxidation by breaking the chain of events leading to the formation of hydroperoxides. This action should also lead to a reduction in DNA damage since the intermediate products of lipid peroxidation include lipid peroxides, which can cause strand breaks in DNA [51]. Significant decrease of vitamin E observed in gasoline filling workers as it is utilized in preventing lipid peroxidation.Insignificant decrease in vitamin C levels was observed in gasoline filling station workers as compared to normal subjects. Powerful antioxidant albumin level in above said workers did not change significantly when compares with the normal subjects [52]. Albumin is the main transporting protein in the the plasma and possesses cysteine residue which enhances its capacity to neutralize peroxyl radicals. Studies linked oxidatitive stress with the exposure of petroleum products [53]

MALIGNANT DISEASES DUE TO PETROL PRODUCTS

The number of epidemiological studies which analyzed risks of malignant disease in association with the petroleum industry have

burgeoned in recent years. This mass of data has not led to any firm conclusions. However, certain statements can be made with some degree of confidence.There is no indication that working in the gasoline industry - particularly refining processes - leads to any dramatic excess of cancers in general and most cancer sites in particular. There is some corroborative evidence from the studies cited here that known carcinogens such as benzene and the polynuclear aromatics have resulted in some excess of leukaemia and basal and squamous carcinoma in limited numbers of petroleum industry workers, but these findings are not consistent across even the best designed studies. Of the remaining cancer sites where excesses have been found in one or more studies, the evidence of a link with kidney cancer remains weak with few cohort studies exhibiting excess and with the best case referent study showing no excess. Interestingly, some workers reported a reversal of the normal bladder kidney dominance for genito-urinary cancers. For brain cancer, the highest excesses found in the studies weakest on methodology. Nevertheless, modest excesses are found in some well planned studies and corroborative evidence linking solvent exposure with brain cancer exists elsewhere in the literature. The excess risk for pancreatic cancer is rarely statistically significant but cannot be easily ignored with 10 cohort studies showing SMRs ranging from 1.08 to 1.38. Such relatively low excesses must be viewed in the light of low SMRs for "all causes" and "all cancers". However, the pre-eminent message to be drawn from a reading of the epidemiological literature on malignancy and petroleum industries is the methodological flaws.The main concerns must be with the almost uniform poor exposure information, the widespread practice of ignoring latency, the failure to control for confounding, and the relatively low power of many studies. If such shortcomings persist in future publications, it is unlikely that further progress will be made regarding aetiology. Further work, more carefully designed, and larger populations are required to evaluate the significance, if any, of leukaemia and melanoma, as well as cancers of the renal tract, the brain and the pancreas.The oil refinery and distribution industries cannot be given clean bill of health on these cancer sites at present.[54]

CARDIOVASCULAR DISEASES DUE TO PETROL PRODUCTS

Cardiovascular disease is one of the biggest killer in Western society. The most rational conclusion is that refinery workers show no evidence of excess cardiovascular mortality. Where the more specific rubric is coronary heart disease is reviewed, a similar mortality deficit is noted - the exception being an SMR of 1.22 in one of the OCAW reports.[55]

One study of the Standard Oil plant in Indiana reviewed periodic health examination data on 9,955 white male workers Forty-two per cent of the workers had an excess weight (on the Quetelet index), 15% undertook inadequate exercise, 16.5% were hypertensive (diastolic blood pressure above 90 mm Hg) and 20.3% were current smokers.. The researchers were not able to relate this to cardiovascular morbidity nor mortality at the plant.[56] Data from the three Russian studies are hard to interpret. In one, evidence is presented of a rising blood pressure and pulse towards the end of the shift [57]. In another, 60% of the workforce are deemed to be "hypertonic" [58] whilst in study of a Perm City complex, Lebedeva and co-workers found a blood pressure elevation in 14.3% of the 353 workers Such a elevation of blood pressure is in line with the U.S.study but evidence for increased heart size and abnormal ECG are difficult to interpret in the absence of any comparison group.[59].

In short, cardiovascular disease mortality and morbidity does not seem to be in excess in persons working in petrol related industries [54].

RESPIRATORY DISEASES

Respiratory disease mortality is not as common as cardiovascular diseases.In the occupational context, the lung is most exposed organ as toxic materials in the workplace usually gain entry to the body via an airborne route. Nevertheless, the petrochemical industry is not a predominant cause of occupational respiratory disease in the the refinery workers.These workers smoke less than the average and that this is the major determinant of their favourable respiratory disease outcome rather than any direct beneficial effect of refinery work. [54].

OTHER DISEASES DUE TO PETROL PRODUCTS

Not enough literature is available to correlate the petroleum toxicity with skin disorders, reproductive disorders, neuropsychiatric disorders and other diseases.

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