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Hepatic Function and Oxidative Stress Markers among Solid Waste Disposal Workers in Yenagoa, Nigeria: Values and Implications

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Abstract: *Solid wastes are infectious and toxic to humans and the environment. This study was aimed at evaluating hepatic function and oxidative stress markers of solid waste management workers in Yenagoa Metropolis, Bayelsa State.Blood samples was collected from apparently healthy male subjects aged 20-40 years. Biochemical parameters: AST, ALT, Total protein, Albumin, Total and conjugated bilirubin, catalase, glutathione, superoxide dismutase and malondialdehyde were analyzed using spectrophotometer. Results showed statistically significant ($p<0.05$) increase in conjugated bilirubin (6.95±3.89) and AST (14.17 ±4.22) among test sample compared with the control (2.30±1.14 and9.08±2.15 respectively).STotal protein (69.60±5.58) and albumin (37.39±4.89) showed a statistically significant ($p<0.05$) reduction in the exposed subjects when compared with the control (69.60±5.58 and 44.84±5.29 respectively).Furthermore, there was a statistically significant ($p<0.05$) elevation in Total bilirubin (15.53±5.99), conjugated bilirubin (6.95±3.89), and AST (15.53±5.11) among subjects with ≥2years duration compared with <2years (10.01±7.55, 3.92±3.14 and 12.08± 2.09).The antioxidant enzymes glutathione (20.6±4.20) was statistically ($p<0.001$) elevated, whereas Catalase (66.2±19.3) and Superoxide Dismutase (61.9±0.97) showed non- significantly ($p>0.05$) reduction compared with the control (15.7±0.99, 75.7±21.7 and 62.5±7.02 respectively) as well on job duration. Malondialdehyde (7.37±1.57) showed a statistically significant ($p<0.001$) increase when compared with the control group (5.88±0.42). Solid wastes have a negative effect on the liver function and oxidative stress markers in prolonged exposure*

Keywords*: Solid Wastes; Liver function tests; Oxidative stress markers.*

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I. Introduction

Workers in their diverse places of work face occupational hazards due to exposure to physical, chemical or biological agents that are detrimental to human health (1). Solid waste handling is an issue of concern everywhere in the world, particularly in all urban areas (2). The activities of humanscreate wastes and the ways these wastes are stored and disposed can pose a lot of threat to the environment which in turn impacts on the health of the individuals (3). The collection of waste from homes, factories/industries, hospitals for disposal in municipal dumpsite is a practice all over the world. These collectors (workers) are exposed to hazardous wastes from industries, hospitals and households which may contain high amounts of dangerous chemical and/or biological agents since these substances are not recognized and handled as hazardous waste (4).

During disposal and processing in the municipal dump sites, the solid waste workers are exposed to heavy metals such as lead batteries, electrical equipment, and electronic waste, stainless steel or plastic products (5) which are not recycled in Yenagoa.Studies have shown the presence of more than thirty different metals in the incinerated ash of untreated urban waste including lead, mercury, arsenic, cadmium, and chromium which are allharmful to human health (6). Waste disposal workers may be exposed to heavy metals by inhalation or ingestion or through skin contact (7). Lead and mercury compounds may damage body organs including the liver if there is prolonged or repeated exposure and harmful if swallowed and inhaled (8). Some gases such as ammonia, sulphur dioxide, nitric oxide, nitrogen dioxide and nitrous oxide are release from waste disposal sites during incineration where workers may become exposed through inhalation or contact with the skin (9). Many of the volatile organic compounds e.g. benzene, toluene, dichloromethane, tetrachloroethylene, trichloroethylene, dichloroethane, phthalates, butadiene and dimethylacetamide found in waste are carcinogenic, mutagenic andreprotoxic chemicals (10).Solid waste generation worldwide had increased significantly over the years and so has the range of toxic and hazardous materials within the waste stream (11). In most cities in

Nigeria, solid wastes are dumped indiscriminately on the roads and streets, forming refuge hills and posing serious threat to human health (12). To curb this menace, the services of solid wastes workers are required which predisposed them to hazardous health conditions(13).The burning of solid waste has been linked with oxidative stress due to hazardous gases that are released to the atmosphere during the process. Also, inhalation of dust containing heavy metals and contact with heavy metals present in solid wastes has been reported to cause oxidative stress (14) resulting in the formation of Reactive Oxygen Species (ROS) and leads to cellular damage. It is a common site here in Yenagoa to see solid waste disposal workers working on dumpsites where constant burning of solid waste takes place and therefore are exposed.

Several studies have termed the hazards faced by waste workers to include respiratory disorders, gastrointestinal dysfunction and maladies of the skin, mucous membranes, and musculoskeletal system (1). Dounias *et al*. (15) shows higher occurrence of hepatitis A virus in municipal waste workers than non-waste workers. Evidence from the studies by Wachukwu *et al*. (16) and Wachukwu *et al.* (17) shows that occupational exposure to chemicals and biological agents in solid wastes resulted in reduction of liver function (liver damage).In Nigeria, solid wastes management is poor and thus constitutes a major environmental and health problem especially to waste management workers. The risk and consequent hazards on the waste management workers have received little attention. These workers are poorly paid,not provided with the necessary and required safety materials. Thus, they resort to improvise for themselves which in most cases is inadequate. Hence, they become exposed to the potential risks associated with solid wastes. This present study is aimed to assess the effect of solid wastes on hepatic functionand oxidative stress markers of solid waste management workers in Yenagoa, Bayelsa State, Nigeria.

II. Methods

Study Population

A total of ninety (90) subjects all male between the ages of 25 – 50 years were recruited for the study. Of these 60 were solid wastes management workers who had worked for about one (1) to five (5) years. The remaining thirty (30) subjects served as the control who were not involved in the disposal of solid wastes. Subjects who consented to the study and without a medical history of any known metabolic disorders or infections were included for the study. Subjects who do not consent to the study and with a medical history of known metabolic disorder were excluded from the study. Also excluded are cigarette smoker and chronic alcohol drinkers.The ethical clearance was approved by the ethical committee Bayelsa State Environmental Sanitation Authority and the director of the solid waste disposal company (Brikari Limited Company).Also, the individual consent of the waste disposal workers was also obtained before sample collection.

Blood Sample Collection

Blood samples were collected from ninety (90) subjects. A standard clean venous puncture technique was used to collect 10ml of venous blood into a plain tube. The samples were transported to the Research Laboratory of Medical Laboratory Science, Niger Delta University in a cool box containing ice bags. The samples were centrifuged for five (5) minutes at 2500rpm and the supernatant serum was separated into separate tubes. The serum was stored at -20^{0}C and all analyses were carried out within 48hours of sample collection. Total bilirubin (TB), conjugated bilirubin (CB), albumin (ALB), total protein (TP), alkaline phosphatase (AP), aspartate aminotransferase (AST), alanineaminotransferase (ALT) were analysed using reagents from Randox Laboratories, (UK).Randox Diagnostic kits were used for the assay of Superoxide Dismutase (SOD) and Catalase (CAT) activities. The method of Xin *et al*, (18) was used for SOD and that described by Aebi (19) was used for CAT. Reduced glutathione (GSH) was measured employing the modified method of King and Wotton (20). Malondialdehyde in serum was determined by the method of Shah and Walker's(21).

Analysis of Liver Function Parameters:

Total protein and albumin were estimated by Biuret method and Bromocresol Green (BCG) method according to Varely(22). Aspartate aminotransferase (AST) and Alanine aminotransferase (ALT) were determined by dinitrophyenyl hydrazone a coupling spectrophotometric methodas described by Reitman and Frankel (23). Total Bilirubin and conjugated bilirubin were determined spectrophotometrically according to the method described by Jendrassic and Grof (24).

Analysis of Oxidative Stress Markers:

Superoxide Dismutase: The principle is based on the generation of superoxide radicals produced by xanthine and xanthine oxidase which reacts with 2 – (4 – iodophenyl)- 3-(4 - nitrophenyl) – 5-phenyltetrazolium chloride to frorm a red formazon dye. Briefly, to 200µL of the diluted haemolysatewas added 300µL of the mixed substrate and mixed. The 75µL of the xanthine oxidase was added to the reaction mixture and the absorbance measured at 505nm. The superoxize dismutase activity was calculated as stated in the manufacture's instruction. . The enzyme activity was expressed as U/ml

Catalase: Catalase activity was estimated according to the method of Koruliuk et al (25). Briefly, 10µL of the sample was incubated with 100µmol/L of hydrogen peroxide (H_2O_2) in 0.05mmol/L Tris-CHCl buffer at pH 7.0 for 10minutes. Then 50µL of 4% ammonium molybdatewas added rapidly to terminate the reaction and the yellow complex of ammonium molydate and hydrogen peroxide (H_2O_2) formed was then measured at 410nm. One unit of catalase activity was defined as the amount of enzyme required to decompose 1µmol H_2O_2 per min.

Reduced glutathione: The principle is based on reaction of thiols with Ellman's reagent ($5,5^i$ – dithiolbis – (2 – nitrobenzoic acidor or DTNB), cleaving the disulfide bond to give 2 – nitro – 5 – thiobenzoate (TNB^-) which ionizes to TNB^{-2} dianionin water neutral and alkaline pH. Briefly, 15µL of the haemolysate was added to 260µl assay buffer (0.1M sodium phosphate and 1mMEDTA, Ph 8.0) and 5µL Ellman's reagent mixed. The reaction mixture was left to stand for 15min at room temperature. The absorbance of the TNB^{-2} formed was measured at 412nm. The absorbance values were compared with a standard curve generated from known GSH Ellman, (26).

Malondialdehyde in serum was separated and determined as conjugate with TBA. Serum proteins were precipitated by TCA and then removed by centrifugation. The MDA – TBA complex was measured at 534 nm (25). Briefly, 1.0ml reagent 1 (17.5% TCA), reagent 2 (70% TCA) and regent 3 (Thiobarbituric acid 0.6%) was added to 1.0ml of serum and mixed. The reaction mixture was incubated in boiling bath for 15 minutes, allowed to cool, and then let to stand at room temperature for another 20 minutes. Then the tubes centrifuged at 2000 rpm for 15 minutes and the supernatant layer was read at 534 nm. Distilled water was used for the blank. Shah and Walker's, (21). The concentration of MDA (nmol/ml) was calculated by using the following formula: Concentration of the test= Abs (test) –Abs (blank) / 1.56 x 1000000

DATA ANALYSIS

Statistical analysis was done by using descriptive and inferential statistics using chi-square test, one way ANOVA and Multiple Comparison-Tukey Test. The software used in the analysis were SPSS (Statistical Package for Social Sciences) version 17.0. All the results were tested at 5% level of significance.

III. Results

Result showed an increase in serum albumin, conjugated bilirubin and AST statistically significant ($p<0.05$) in the test group compared with control samples. Total protein showed a statistically significant ($p<0.05$) decreasein the test group when compared with the control group.Table 2 shows the values of solid waste on oxidative stress markers of waste management workers in Yenagoa metropolis. The results revealed that glutathione (GSH) (20.6±4.20) and Malondialdehyde (MDA) (7.37±1.57) were increase statistically significance ($p<0.001$) in the test samples when compared with the control (15.7±0.99 and 5.88±0.42) respectively. Superoxide dismutase (SOD) (61.9±0.97) and Catalase (CAT) (66.2±19.3) shows a statistically non-significant ($p>0.05$) decrease in the test group when compared with the control group (62.5±7.02 and 75.7±21.7) respectively.Table 3 shows effect of duration on exposure to solid waste on liver parameters of participants. The result revealed that total bilirubin, conjugated bilirubin and AST shows a statistically significant ($p<0.05$) increase in solid waste workers involved with waste management for over 2years as against those involved in less than two years. Albumin, total protein and ALT showed statistically non-significant different ($p>0.05$).Table 4 shows effect of duration of exposure to solid wastes on oxidative stress markers of the participants. The result revealed that Glutathione (GSH)and Malondialdehyde (MDA)showed a statistically significant ($p<0.05$) increase in solid waste management workers with occupational experience of two years and above as against those involved in less than two years. The Superoxide Dismutase (SOD) andCatalase (CAT) showed a statistically non-significant ($p>0.05$) different.

Table 1: **Assessment of solid waste on liver biochemical parameters of waste management workers in Yenagoa metropolis**

Variables	Control	TEST	P-VALVE
Total protein	69.60±5.58	64.76±4.15	0.04
Albumin	44.84±5.29	37.39±4.89	0.01
Total Bilirubin	11.08±5.21	15.05±5.99	0.36
Conjugated Bilirubin	2.30±1.14	6.95±3.89	0.03
AST	9.08±2.15	14.17 ±4.22	0.04
ALT	8.59±3.13	9.05±2.09	0.22

KEY: NS =Not Significant; S= Significant**.** Results are expressed as Mean ± Standard Error of Mean (SEM).

Table2: EvaluatioEn of Solid waste on oxidative stress markers of waste management workers in Yenagoa metropolis

Variables	CONTROL	TEST	P -Value
Glutathione (GSH)	15.7±0.99	20.6±4.20	<0.001
Catalase (CAT)	75.7±21.7	66.2±19.3	>0.05
Superoxide Dismutase	62.5±7.02	61.9±0.97	>0.05
Malondialdehyde (MDA)	5.88±0.42	7.37±1.57	<0.001

KEY: NS =Not Significant; S= Significant**.** Results are expressed as Mean ± Standard Error of Mean (SEM).

Table3: Effect of Duration of exposure to solid waste on Liver biochemical parameters of waste management workers in Yenagoa metropolis

Variables	<2 years	≥2 years	P-value
Total protein	63.74±3.23	64.76±4.15	0.68
Albumin	47.11±2.31	46.84±5.29	0.91
Total Bilirubin	10.01±7.55	15.05±5.99	0.02
Conjugated Bilirubin	3.92±3.14	6.95±3.89	0.04
AST	12.08±2.09	15.53±5.11	0.05
ALT	8.17±3.29	9.17±2.12	0.81

KEY: NS =Not Significant; S= Significant**.** Results are expressed as Mean ± Standard Error of Mean (SEM).

Table 4: **Effect of Duration of Exposure to solid waste on oxidative stress markers of waste management workers in Yenagoa metropolis**

Variables	< 2 years	≥2 years	p.value
Glutathione (GSH)	21.6±3.27	23.72±0.01	0.00
Catalase (CAT)	67.0±9.34	67.6±11.6	0.23
Superoxide Dismutase	59.7±8.22	62.8±2.23	0.53
Malondialdehyde (MDA)	6.83±1.17	8.13±0.96	0.00

KEY: NS =Not Significant; S= Significant**.** Results are expressed as Mean ± Standard Error of Mean (SEM).

IV. Discussion

Increased exposure to hazardous substances such as gases, metals, polycyclic aromatic hydrocarbons (PAH), chlorinated hydrocarbons, pesticides, dioxins, asbestos, pharmaceuticals and pathogens as well as other biomedical wastes in waste management portend serious health risks to human (27).The results obtained in this study confirmed that solid waste has a considerable effect on the liver function parameters and oxidative stress markers among solid waste management workers.

The health status of an organ is better appreciated from its enzyme makers. The liver enzymes such as AST, ALT, ALP and GGT are known to have law serum concentrations (28, 29). The primary site of AST is the liver with only trace amount in skeletal muscles and heart. AST is found in the cells cytoplasm and mitochondria from where it take part in protein metabolism. It leaks out of damaged tissues in hepatocellular necrosis into the general circulation (30, 31). In the event of damage to liver parenchyma cells, these enzymes leak from the intracellular compartments into the blood/plasma resulting in elevated concentration in the plasma. Studies have shown that heavy metal (including cadmium, mercury, arsenic and others) are hepatoxic. Arsenite intoxication of rats induced hepatocyte membrane damage causing leakage of ALT, AST and ALP into circulation as well as causing focal necrosis in the liver (32). In the present study, there was a significant elevation of AST and a non-significant elevation of ALT in the exposed subjects compared to the non-exposed subjects. This could have been due to the interaction of the toxic metals with the parenchyma cells of the liver, which could have resulted in necrosis. This is in agreement with the study by Lee et al (33), Mahour and Saxena (34). They reported marked elevation of serum activities of liver enzymes in rats intoxicated with toxic metals. Jagadeesan and Sankaramipillal (35) also observed elevated serum activities of liver enzymes in albino rats intoxicated with Hgcl. Our findings also agrees with the observations by Wachukwu et al. (16, 17) who reported a statistically significant increase in Aspartate Transaminase (AST) activities on prolonged exposure to solid wastes of solid waste management workers.

Furthermore, toxic metals are known to have deleterious effects on hepatic functions, biosynthetic ability and integrity of hepatocytes. The concentration of total protein and albumin are decreased in liver disorder due to a reduction in the number of hepatocytes and impaired (36, 37). It is known that in liver cirrhosis, all liver synthesized proteins are decreased while globulin is increased due to imposed kutffer cell function and acute phase protein production. However, the liver has the reserve capacity to maintain protein concentration and the protein concentration can only decline in extensive liver damage. Also many liver proteins have long half-life. Albumin has a half-life of 21 days. The rate at which decrease protein synthesis occur in the liver is dependent on the type, severity and duration of liver injury. In acute hepatic dysfunction there is little or no change in the total plasma protein concentration (38). The present study reveals that the exposed subjects have a significantly reduced serum albumin concentration compared with control. This may be because hepatocytes, which are involved in the synthesis of these proteins, have a minimum turn over and a lifespan of about one year (39)..

One of the functions of the liver is to conjugate indirect bilirubin from destroyed erythrocytes in the reticule-endothelial system. The bilirubin is taken to the liver bound to albumin and is taken up by the hepatocytes which then conjugate them to bilirubin diglucuronide by the action of the enzyme uridyl diphosphate glucuronyltransferase. This conjugation enable bilirubin to be excreted in the urine. Injury to the hepatocytes results in an increase in the total bilirubin concentration. Diseases and or assault on the liver hepatocytes may reduce the conjugating function of the liver. Also, obstruction to the flow of bile from the bile canaliculi may as well cause an increase in serum bilirubin. In a study on mercury intoxication using rat model, it was observed that serum total bilirubin was elevated (40). In another study using animal model, it was also observed that mercury intoxication elevated serum total bilirubin concentration (41). Cadmium caused an increased level of bilirubin in conjunction with ALT, AST, ALP and Y-GT (42). In the current study, total bilirubin and conjugated bilirubin were elevated with conjugate bilirubin been significant compared with the control subjects. The increase in both TB and CB in the exposed subjects could be due to haemolysis which may be secondary to erythrocyte membrane lipid peroxidation. Studies have implicated some metals e.g Gold, Mercury, Copper and lead to cause lipid peroxidation (43). Increased release of haemoglobin from erythrocytes heamolysis may explain the higer values of TB and CB in the exposed subjects. The significant difference observed in serum total bilirubin, TP, ALB and CB in the exposed subject indicate/implied that the biosynthetic capacity and biotransformation function of the liver in the exposed subject may be affected. The elevation in the liver enzymes with marked elevation in AST is an indication that the liver may be undergoing necrosis as a result of its interaction with toxic metals in the waste. This finding is in agreement with Godwin et al. (44) who reported a slight non-significant increase in total bilirubin and conjugated bilirubin.nOur findings also agrees with the observations by Wachukwu et al. (16, 17) who reported a statistically significant increase in Conjugated Bilirubin levels in solid waste management workers.

Oxidative stress Markers

Catalase is an antioxidant enzyme found in almost all living tissues that utilizes oxygen. It catalyses the degradation of hydrogen peroxide (H_2O_2) to water and oxygen. Catalase is a very vital enzyme involve in protecting living cells from oxidative damage. In this study, a non-significant reduction of catalase activities was observed in exposed subjects compared with the non-exposed subjects. However, this reduction may become significant upon prolong exposure to solid waste. The reduction observed may be linked to the presence of toxic metals such as cadmium and arsenic generated in solid wastes. It has been reported that cadmium and arsenite inhibits the activities of antioxidant enzymes especially catalase (45, 34). The decrease in the catalase activity may be due to the binding of cadmium or arsenic to sulfhydryl groups involved in the catalytic action of the enzyme, thus inhibit their activities or it may act by inducing the deficiency or substitution of essential ions and thus decrease the synthesis and activities of the catalase enzyme. Our finding is in agreement with Godwin et al. (46) who reported a significant decrease in catalase activities on subjects exposed to E-wastes. It also agrees with the observations of Rajarshi et al. (46) who confirmed a decrease in antioxidant enzyme activities on cadmium exposed induced oxidative stress mice.

Superoxide dismutase (SOD) is a vital endogenous antioxidant enzymes that acts as a component of first line defense against reactive oxygen species (ROS). SOD is a metallo-enzyme and hence requires a metal cofactor (copper and zinc, or manganese, iron, or nickel) for its activities. In biological systems, the main reactions of superoxides are with itself or with another biological radical such as nitric oxide (NO) or with a transition series metal. The superoxide anion radical (O_2) spontaneously dismutates to O_2 and hydrogen peroxide (H_2O_2) quite rapidly. SOD is important because superoxide reacts with sensitive cellular targets to cause pathological conditions (47). In the present study, a non-significant reduction of SOD activities was observed in exposed subjects compared with the unexposed subjects. However, this slight reduction may become statistically significant upon prolong exposure. The reduction of SOD observed may be associated with some toxic metals such as lead, cadmium and mercury generated in solid wastes. It is reported that lead, cadmium and mercury exposure may account for the slight reduction of SOD activities in the exposed subjects (45). Copper is a cofactor for SOD and its deficiency causes decrease SOD activity. Involvement of mercury in oxidative stress may be due to its ability to displace copper from its binding site. It has been suggested that mercury increases intracellular copper only by increasing influx from extracellular medium which could particularly increase oxidative stress (48). Our finding is in agreement with Godwin et al. (44) who reported a significant decrease in SOD activities on subjects exposed to E-wastes.

GSH play a significant role in the detoxification and excretion of heavy metals. It binds with heavy metals to form a water-soluble chemical which is more readily excreted out of the body. (49). In the present study, GSH was significantly elevated in the test subjects compared with the control. Studies have shown that the expression of γ-glutamyl cysteinyl synthase, the rate limiting enzyme in GSH synthesis, is modulated by oxidants and phenolic antioxidants in various mammalian cells [50). The raised GSH in our study could be explained on the bases that the exposed worker have evolved mechanism that leads to the induction of enzymes of GSH synthesis. However, some researchers reported a marked decreased level of GSH due to lead exposure which is a component of solid waste (51).

Malondialdehyde (MDA) is a product of lipid peroxidation and provides a means of accessing the degree of lipid peroxidation. Several studies have established lipid peroxidation secondary to heavy metal (lead, mercury, arsenic, cadmium and chromium) toxicity. In the present study, a significant increase in malondialdehyde (MDA) was observed in the solid waste workers when compared with the non-workers. This increase in MDA may be associated with the presence of the toxic metals generated in solid wastes. These metals have high affinity for cell membranes and mitochondria phosphorylation (52). This lead to the production of reactive oxygen species (ROS) and thus causes the imbalance of pro-oxidants and antioxidant balance called oxidative stress. The accumulative oxidative stress produced by exposure to solid waste causes damage of cellular components including DNA damage, DNA mutation and transformation to malignant cell. Our finding is in agreement with Gargy et al. (53) who reported an elevated level of lipid peroxidation in children working in garbage dupsite. It also concur with the findings of Godwin et al. (44) who revealed a significantly elevated lipid peroxidation in E-waste workers.

V. Conclusion

The evaluation of the hepatic function parameters and Oxidative stress markers in solid waste management workers shows that solid waste has considerable effect on the liver function and oxidative stress markers. However, this considerable effect becomes more significant with prolonged exposure to the solid waste.

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