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ASSESSMENT OF COGNITO-MOTOR ACTIVITIES OF RATS EXPOSED TO MILD CRUDE OIL TOXICITY

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ABSTRACT
This study examined the possible neurotoxic effects of Nigerian Bonny Light Crude Oil (NBLCO) by assessing antioxidant levels and cognito-motor functions in rats. Thirty healthy male and female albino rats of 12 weeks old weighing between 80-200g were used in this study. The rats were divided into four groups with group I serving as control, and were oral gavaged (distilled water at 1ml/kg body weight as placebo. Group II, III, and IV were given (0.5, 1, and 1.5ml/kg) body weight of NBLCO respectively by oral route. After the treatment period of six weeks, the animals were sacrificed and blood samples collected for analysis for markers of oxidative stress. The animals also underwent series of tests to assess their cognito-motor functions. The results obtained showed significant ($P \leq 0.05$) increase in superoxide dismutase (SOD), malondialdehyde (MDA), and catalase (CAT) levels in serum when compared to control. Glutathione oxidase levels were significantly ($P \leq 0.05$) lower in all the test groups when compared to control. The levels of protein decreased significantly ($P \leq 0.05$) in group IV but decreased marginally in groups II and III. The mean time taken to finish the navigation maze test was significantly higher in all the test groups (on all three trials) when compared to control. Results for hand-grip tests showed that significant decrease in all the test groups when compared to control. The mean time taken to cross the beam was significantly ($P \leq 0.05$) higher in all the test groups when compared to control. The larger implications of these findings suggest oxidative stress induced by crude oil with consequent decline in neuronal functions in the rats. It is therefore concluded that chronic ingestion of crude oil has the potential to induce oxidative stress, which may lead to cognito-motor dysfunction. Future studies will focus on the precise role of oxidant molecules in Listeria in neuro-pathogenesis. This work increases our understanding of the possible role of crude oil misuse in neurodegenerative processes including memory loss.

KEYWORDS: Crude oil, Neurotoxicity, Handgrip, NBLCO, Cognito-motor, Navigation.

INTRODUCTION
Exposure of humans to chemicals in crude oil can occur through inhalation of contaminated air, skin contact, and ingestion of contaminated food or water (Burns and Harbut, 2010). Interestingly, folkloric application of Nigerian bonny light crude oil (BLCO) by the local population includes skin application for foot rot, burns, and leg ulcers; oral ingestion for poisoning and witchcraft, and in the treatment of gastrointestinal ailments (Adedara *et al*., 2012).

Experimental evidences show that BLCO causes damage to different body tissues and organs. These include the testes, sperm, liver, kidney, and erythrocytes, by inducing oxidative stress (Farombi *et al*., 2010). Damage to these tissues, organs and systems can cause a wide range of diseases and health conditions. Some may be immediately evident whereas others might appear months or years following exposure (Burns and Harbut, 2010).

The brain is particularly susceptible to oxidative damage because of its high content of oxidative polyunsaturated fatty acids (PUFAs); its high oxygen consumption. Consequently, oxidative stress marked by excessive levels of ROS is associated with neurodegeneration (Valko *et al*., 2007).

Furthermore, Aguilera and colleagues earlier reported that exposure to spilled oils may result in the appearance of acute neurotoxic effects in exposed individuals (Aguilera *et al*., 2010). These include anxiety, depression scores, worse mental health, and self-reported headache (Aguilera *et al*., 2010). However, the mechanisms through which components of crude oil, such as the long-

chain aliphatic hydrocarbons and PAHs might affect the brain are unclear.

While Takeda, and colleagues report that neurotoxicity might result from DNA damage leading to activation of apoptotic pathways (Takeda *et al*., 2004); Lundqvist and colleagues suggest that epigenetic effects, or oxidative stress resulting from inhibition of the brain's antioxidant-scavenging mechanisms could be responsible (Lundqvist *et al*., 2006).

Brain tissues are highly sensitive to toxicity by environmental contaminants (Nijland *et al*., 2008). The neuro-chemical factors responsible for stress-induced neurological disorders are still poorly characterized; however, increasing evidence suggests an important role for bio-metals in neuronal degenerative processes (Valko *et al*., 2010).

With this background, the present work was designed to evaluate the neurotoxic effect of BLCO by investigating both the brain levels of oxidative stress biomarkers and cognito-motor performance of BLCO-treated rats.

As only few studies show the degree of oxidative stress at tissue level, the present study aimed to determine the status of oxidative stress by measuring brain levels of antioxidant enzymes, i.e., SOD and CAT, MDA, GSH, in the animals. Further, cognito-motor performances shall be evaluated.

Crude oil is mixture of hydrocarbons. It contains mainly aliphatic, and aromatic hydrocarbons spanning the carbon number range from C1 to C60+. Moreover, it contains oxygen, sulphur, and nitrogen compounds and dissolved gases, such as hydrogen sulphide (CONCAWE, 2001).

The composition of crude oil is as follows: Carbon – (83-87%), Hydrogen (10-14%), Nitrogen (0.1-2%), Oxygen (0.1-1.5%), Sulphur (0.5-6%), Metals (<0.1%) (CONCAWE, 2001).

Cognito-motor Activities: A motor activity is an action involving a person using his muscles. Motor skills are needed in order to perform motor activities. Motor activities are classified as gross/crude or fine.

Gross/crude motor activities are those that require the use of large muscles (e.g. those used for walking, kicking, or moving the arms. Examples of crude locomotor skills would include running, jumping, sliding, and swimming.

On the other hand, **fine motor** activities are smaller actions involving highly precise movements such as that require finger maneuvering. Examples of fine motor activities include picking writing, writing carefully, and even blinking and tying shoes.

MATERIALS AND METHODS

Research Design

30 Wistar rats were shared into eight groups as follows;

- Group 1: control (Received normal feed and saline water)
- Group 2 : Received NBLCO contaminated feed at (0.5ml/kg b.w)
- Group 3: Received NBLCO contaminated feed (1ml/kg b.w)
- Group 4: Received NBLCO contaminated feed (1.5ml/kg b.w)

A good laboratory practice protocol was observed when all experiments were conducted. Quality standards of biomedical research were noted and implemented. This research study lasted for six (6) weeks which comprises of two weeks of acclimatization and four (4) weeks of administration. Before rats in the three test groups were engaged in cognito-motor tasks, the rats in group I were oral gavaged distilled water at 1ml/kg body weight as placebo. Group II, III, and IV received (0.5, 1, and 1.5ml/kg) body weight of BLCO respectively by oral route.

The Animals were sacrificed after the fourth week of administration. Cortical tissue samples were collected from two animals in each of the groups. The tissue samples were crushed and homogenized using 0.9 NaCl normal saline and passed through enzymes evaluation. And this Analysis took place at the Research Laboratory of the department of Biochemistry, University of port Harcourt.

Malondialdehyde (MDA) was estimated using spectrophotometry (Ohakawa et al.,1979). Glutathione level was determined using spectrophotometry (Aebi, 1974). Catalase activity was estimated using spectrophotometry according to Aebi (Aebi, 1974). Superoxide Dismutase (SOD) activity was determined using auto-oxidation method (Ohakawa et al.,1979).

2.2 Animals

Wister rats were considered the choicest animals for this experiment due to its availability, cost, genetic makeup, its handling technique and type of the study. Thirty healthy rats of 12 weeks old weighing between 150-200g were used in this study. These animals were gotten from the Experimental Animal Unit of Department of Human Physiology, UNIPORT, Rivers State. The rats were housed in conventional wire mesh cages under standard laboratory conditions.

The animals were allowed free access to water and feed throughout the period of the experiment. The animal feed was gotten from Rumuosi local market Port Harcourt. Constituents of the animal feed are: Maize grains, Wheat brand, Groundnut, Palm kernel, Fish meal. It also contains minerals like sodium and magnesium.

After the collection of the animals, they were weighted and identified and kept in a wire gauge cage floored with saw dust to maintain dryness, under favourable condition for two weeks. The animals were feed and handled regularly so as to acclimatize with the handling and environment of human physiology.

Nigeria Bonny Light Crude oil (NBLCO) was obtained from Nigerian National Petroleum Corporation (Port Harcourt, Rivers State, Nigeria).

Cognitive and Motor Function Tests

Cognitive and motor functions were carried out on the experimental animals with the following equipment;

- Navigation test
- Elevated maze test
- Hand grip test
- Beam walking

Statistical Analysis

SPSS version 20.0 was used for analysis of data, the results were expressed as mean ±SEM. One-way Analysis of Variance (ANOVA) and Post Hoc Test were used to compare the mean and P-Value ≤ 0.05 was accepted as statistically significant.

RESULTS

Table 1. Assessment of stress Bio-markers in rats on exposure to mild crude oil administration in simulated polluted hood.

GROUPS	Superoxide dismutase (u/ml)	Malonaldehyde (µg/ml)	Protein (g/L)	Glutathione oxidase (µg/ml)	Catalase (u/g)
GROUP 1(control)	155.17±27.25	33.18±4.20	12.51±0.74	54.89±1.66	16.00±26.94
GROUP 2 (0.5 ml/kg b.w.)	348.88±69.38*	53.43±0.25*	11.70±0.71	13.62±1.70*	24.00±7.35*
GROUP 3 (1 ml/kg b.w.)	448.46±101.52*	55.10±14.34*	10.08±2.03	13.65±5.56*	28.00±7.35*
GROUP 4 (1.5 ml/kg b.w.)	658.88±50.16*	65.86±4.94*	6.30±1.36*	13.62±1.14*	112.00±2.45*

(Values present in mean ± sem. n= 5. P ≤ 0.05 *means values are statistical significant compared to control. KEY: Group 1 (distilled water at 1ml), Group 2 (NBLCO at 0.5ml/kg b.w.), Group 3 (NBLCO at 1ml/kg b.w.), Group 4 (NBLCO at 1.5ml/kg b.w.). NBLCO = Nig. Bonn. Li. Crude Oil)

Superoxide dismutase (SOD): From the results, the mean concentrations of superoxide dismutase (SOD) for groups I, II, III, and IV are (155.17, 348.88, 448.46, and 658.88) u/ml respectively. These results indicate that SOD brain levels were significantly (P ≤ 0.05) higher in all test groups when compared to control. (Table 4.1)

Malonaldehyde: The mean malonaldehyde concentrations in groups I, II, III, and IV were (33.18, 53.43, 55.10, 65.86) µg/ml respectively. The results revealed that all test groups had significant P ≤ 0.05 higher malondialdehyde levels compared to control. (Table 4.1).

Protein: The mean protein levels in groups I, II, III, and IV were (12.51, 11.70, 10.08, 6.30) g/L respectively. Group IV had a significantly (P ≤ 0.05) lower value compared to control. However, the values for groups II, and III, were only marginally lower compared to control. (Table 4.1)

Glutathione oxidase: The mean glutathione oxidase levels in groups I, II, III, and IV were (54.89, 13.62, 13.65, 13.62) µg/ml respectively. All test groups had significantly (P ≤ 0.05) higher values when compared to control. (Table 4.1).

Catalase: The mean catalase levels in groups I, II, III, and IV were (16.00, 24.00, 28.00, 112.00) u/g respectively. The values for all test groups were significantly (P ≤ 0.05) high compared to control. (Table 4.1)

Cognito-motor Activities

Table 2. Assessment of cognito-biomotor activities in rats on exposure to mild crude oil administration in simulated polluted hood using Navigation Maze Test.

	THREE SUCCESSIVE EXPOSURE AT 7 DAYS INTERVAL		
GROUPS	**TRIAL 1 (s)**	**TRIAL 2 (s)**	**TRIAL 3 (s)**
GROUP 1(control)	44.80±12.38	16.00±1.92	43.60±9.13
GROUP 2 (0.5 ml/kg b.w.)	99.20±52.03*	158.00±59.78*	218.00±52.19*
GROUP 3 (1 ml/kg b.w.)	227.00±45.27*	261.60±38.40*	207.00±57.00*
GROUP 4 (1.5 ml/kg b.w.)	300.00±0.21*	250.60±49.40*	300.00±0.35*

Values are presented in mean ± sem. n= 5. P ≤ 0.05 *means values are statistically significant when compared to the control. KEY: Group 1 (distilled water at 1ml), Group 2 (NBLCO at 0.5ml/kg b.w.), Group 3 (NBLCO at 1ml/kg b.w.), Group 4 (NBLCO at 1.5ml/kg b.w.). NBLCO = Nigerian Bonny Light Crude Oil.

Navigation Maze Test: Three successive exposures at 7 days intervals were done.
First trial: The mean time values for groups I, II, III, and IV were (44.80, 99.20, 227.00, 300.00) seconds respectively. The results show that groups II, III, and IV had values significantly ($P \leq 0.05$) higher when compared to control. (Table 4.2).

Second trial: The mean time values for groups I, II, III, and IV were (16.00, 158.00, 261.60, 250.60) seconds respectively. The values for groups II, III, and IV were significantly ($P \leq 0.05$) higher when compared to control. (Table 4.2).

Third trial: The mean time values for groups I, II, III, and IV were (43.60, 218.00, 207.00, 300.00) seconds respectively. (Table 4.2). Values obtained were significantly (($P \leq 0.05$) higher when compared to control.

Hand Grip Test

Table 3. Assessment of cognito-biomotor activities in rats on exposure to mild crude oil administration in simulated polluted hood using Hand Grip Test.

	THREE SUCCESSIVE EXPOSURE AT 7 DAYS INTERVAL		
GROUPS	**TRIAL 1 (s)**	**TRIAL 2 (s)**	**TRIAL 3 (s)**
GROUP 1(control)	116.80±25.88	136.40±8.95	125.80±3.83
GROUP 2 (0.5 ml/kg b.w.)	13.00±1.79*	11.40±1.50*	8.80±0.97*
GROUP 3 (1 ml/kg b.w.)	12.20±2.01*	8.60±0.57*	7.40±0.68*
GROUP 4 (1.5 ml/kg b.w.)	55.60±17.76*	48.60±18.55*	16.20±1.56*

Values are presented in mean ± sem. n= 5. $P \leq 0.05$ *means values are statistically significant when compared to the control. KEY: Group 1 (distilled water at 1ml), Group 2 (NBLCO at 0.5ml/kg b.w.), Group 3 (NBLCO at 1ml/kg b.w.), Group 4 (NBLCO at 1.5ml/kg b.w.). NBLCO = Nigerian Bonny Light Crude Oil.

Three successive exposures at 7 days interval were done.
First trial: The mean time values for groups I, II, III, and IV were (116.80, 13.00, 12.20, 55.60) seconds respectively. The results shows that groups II, III, and IV had values significantly ($P \leq 0.05$) lower compared to control. (Table 4.3)

Second trial: The mean time values for groups I, II, III, and IV were (136.40, 11.40, 8.60, 48.60) seconds respectively. The values for groups II, III, and IV were significantly ($P \leq 0.05$) lower when compared to control. (Table 4.3)

Third trial: The mean time values for groups I, II, III, and IV were (125.80, 8.80, 7.40, 16.20) seconds respectively. (Table 4.3). Values obtained were significantly ($P \leq 0.05$) higher when compared to control.

Beam Walking Test

Three successive exposures at 7 days interval were done. Values presented here represent the average time it took to cross the beam.

Table 4. Assessment of cognito-biomotor activities in rats on exposure to mild crude oil administration in simulated polluted hood using Beam Walking Test.

	THREE SUCCESSIVE EXPOSURE AT 7 DAYS INTERVAL		
GROUPS	**TRIAL 1 (s±sem)**	**TRIAL 2 (s±sem)**	**TRIAL 3 (s±sem)**
GROUP 1(control)	34.60±6.74	51.40±18.29	52.20±9.45
GROUP 2(low dose)	92.00±11.00*	101.20±13.41*	71.60±5.49*
GROUP3 (medium dose)	161.00±34.82*	154.60±18.80*	205.20±42.10*
GROUP 4 (high dose)	212.60±25.01*	274.80±14.87*	284.40±15.60*

Values are presented in mean ± sem. n= 5. $P \leq 0.05$ *means values are statistically significant when compared to the control. KEY: Group 1 (distilled water at 1ml), Group 2 (NBLCO at 0.5ml/kg b.w.), Group 3 (NBLCO at 1ml/kg b.w.), Group 4 (NBLCO at 1.5ml/kg b.w.). NBLCO = Nigerian Bonny Light Crude Oil.

First trial: The mean time values for groups I, II, III, and IV were (34.60, 92.00, 154.60, 274.80) seconds respectively. The results shows that groups II, III, and IV had values significantly ($P \leq 0.05$) higher when compared to control. (Table 4.4).

Second trial: The mean time values for groups I, II, III, and IV were (51.40, 101.20, 154.60, 274.80) seconds respectively. The values for groups II, III, and IV were significantly ($P \leq 0.05$) higher when compared to control. (Table 4.4).

Third trial: The mean time values for groups I, II, III, and IV were (52.20, 71.60, 205.20, 284.40) seconds respectively. (Table 4.4). Values obtained were significantly ($P \leq 0.05$) higher when compared to control.

DISCUSSION

Assessment of cognito motor activities in rats exposed to mild crude oil administration in simulated oil impacted hood was investigated and findings reported in this section.

Superoxide Dismutase (SOD)
Crude oil ingestion caused a dose-dependent increase in brain levels of **superoxide dismutase** an oxidative stress biomarker.

Assessment of these cellular antioxidants helps in monitoring oxidative stress. Alteration in antioxidant pattern, with significantly ($P \leq 0.05$) high levels of superoxide dismutase (SOD) was observed in the brain of test groups compared to control (Table 4.1).

An earlier study done by Mari-Carmen and colleagues, suggested that free radical overproduction might cause an up-regulation of powerful antioxidant enzymes. Two important enzymatic antioxidants that scavenge free radicals are superxide dismutase and catalase (Mari-Carmen, *et al* 2007.

Cells may respond to oxidative stress by over-expressing certain enzymatic antioxidants. Evidence indicate continued presence of small stimuli such as low concentration of oxygen radicals can induce the expression of antioxidation enzymes.

The physiologic basis for this phenomenon could be explained by the concept of hormesis (Calabrese and Baldwin, 2003). Homeosis describes a dose-response relationship in where low dose of substance stimulate and high dose inhibit. In this context, oxygen radicals can be seen as beneficial, since it acts as a signal to enhance defense, rather than as harmful, as when cells encounter high concentrations of radicals.

Malonialdehyde (MDA)
Increase in brain MDA levels in test groupings indicate the increasing oxygen radical activity and oxidizing stress. The significant ($P \leq 0.05$) high MDA in all test groupings imply that membrane lipids were attacked.

MDA forms from lipid peroxidation, and has been used as an oxidative stress marker.

Lipid peroxidation is a major source of oxygen radical-mediated injury that directly damages neuronal membranes producing a number of secondary products that cause extensive cellular damage. Oxygen radical attack to PUFAs results in generation of highly reactive aldehydes, including malondialdehyde (MDA), an abundant product (Musiek *et al*, 2005).

A major target for lipid peroxidation process is the central nervous system (CNS). Actually, the brain is very sensitive to oxidative stress because it consumes about 20–30% of inspired oxygen; contains high levels of poly-unsaturated fatty acids (PUFAs); thus, it is an ideal target for oxygen radical attack. (Rukhsana, 2013).

In addition, it has been reported that markers of lipid peroxidation have been found to be elevated in brain tissues and body fluids in several neurodegenerative diseases, including Alzheimer disease (AD), Parkinson disease (PD), Huntington disease (HD), and Down syndrome (DS) (Shichiri, *et al*, 2011).

In agreement with these findings, several reports have documented elevated levels of reactive lipid peroxidation products parts of the brain but not in parts not involved in the disease (Butterfield *et al*, 2010).

Protein
A dose-dependent decline in the brain tissue levels of **protien** was recorded in the present study. Earlier studies have shown that oxidative stress caused by exposure to H_2O_2 results in a rapid and reversible inhibition of protein synthesis (Shenton and Grant, 2003).

Hydrogen Peroxide, a major oxygen radical, inhibits protein synthesis. In an earlier study, cells were treated with H_2O_2 for fifteen (15) minutes, and then the rate of protein synthesis was measured during the final 5 min by the attachment of [35S] cysteine/methionine. H_2O_2 caused a dose-dependent inhibition of protein synthesis. (Daniel *et al*, 2006).

The potency of crude oil in decreasing protein synthesis significantly shows that crude oil could impair learning and memory processes since these processes involve synthesis of new proteins and establishment of new synapses.

Glutathione (GSH)
Glutathione, a powerful antioxidant, plays a key role in the ability of the brain to scavenge oxygen radicals involved in oxidative stress. Protection against oxidative injury is directly afforded through glutathione oxidation in mitochondria (Sastre, *et al*, 2000), GSH depletion occurs in the pathogenesis of virtually all neurodegenerative disorders. Considering recent clinical studies, which show that GSH depletion occurs prior to neurodegeneration, neuronal GSH depletion may play key role in neurodegenerative changes and subsequent cognito-motor deficits.

Findings from this study are consistent with reports from an earlier study that ascertained that glutathione reduction is indicative of brain tissue undergoing oxidative stress. (In-Young *et al*, 2014).

A significantly increased oxygen radical generation and cell stress with inflammation commonly accompany neurodegenerative disorders, and the resultant burden on the brain's antioxidant defense mechanisms may likely be reflected by reductions in concentrations of GSH (Choi *et al*, 2011). Reduced levels of intracellular GSH leads to reduced cell protection against oxidative stress even in cultured neurons (Himi *et al*, 2003).

Even more interesting is the observation that GSH-deficient mice manifest brain atrophy, spatial

learning/memory dysfunction, and movement disorder at advanced ages (Koji and Toshio, 2013).

Catalase (CAT)
CAT is a powerful oxygen radical scavenger of mammalian cells. (Tarozzi *et al*, 2007). This enzyme catalyzes the detoxification of hydrogen peroxide by converting it to water and oxygen gas.

Catalase is indispensable in oxygen radical detoxification in stress, when elevated levels of oxygen radicals are generated (Kwon *et al*, 2011). Moreso, oxidative stress induces peroxisomes proliferation (Li *et al*, 2008).

The elevated brain tissue levels of catalase, in this study, could possibly be a compensatory response to increased H_2O_2 concentrations in crude oil-stressed animals. The protective potential of catalase over-expression is consistent with the proposal, based on in vitro study, that lactate-Fe3 complexes induce the conversion of H2O2 into (OH) into hydroxy radicals via Fenton reaction (Heo *et al*, 2009).

Navigation Maze Test
The navigation maze test was done to evaluate the ability of experimental animals to learn and memorize. Findings from this study indicated significant degrees of cognitive impairments in crude oil-treated rats. This cognito-motor impairment in the rats is suggestive of oxidative injury to certain regions/areas of the brain normally involved in such functions.

In an earlier study, age-related loss of capacity to do swim maze task was reported to be positively associated with oxidative damage to cerebral cortex, while age-related loss of motor skills was associated with oxidative damage occurring in cerebellum.

Accordingly, these finding is in line with the view that oxidative stress is a principal cause of brain senescence.

In addition, the results indicate that age-related decline in cognitive and motor function progress independently, since they involve oxidative damage to different brain regions.

Selection of navigation test was based on findings that difficulty in learning and remembering locations in space is a crucial component of oxidant-induced cognitive deficit, which can be evaluated in both animals and humans.

Although the functional associations established in the present study by themselves cannot conclusively establish a link between oxidative injury and brain dysfunction. It may, however, be possible that brain dysfunction and oxidative injury show substantial correlation by way of association with certain neurodegenerative processes. Nevertheless, the current findings add substantial support to other lines of evidence supporting a causal relationship.

The cortex clearly represents one area thought to be involved in age-associated cognitive loss, and experimental damage to cortical areas in young animals is sufficient to produce impairment in spatial discrimination learning.

Beam Walking
Performance on the beam is a useful measure of examining fine control skills and balance.

In all three trials, the test grouping animals took significantly longer time durations to cross the beam compared to control. This is indicative of impaired balance and coordination possibly caused by ROS-induced neurotoxicity. This is most likely to result from oxidant damage to the cerebellum since this area of the brain coordinates fine motor movements.

Buccafusco had earlier stated that mice with cortical impact lesions often exhibit contralateral slipping on the beam (Buccafusco 2009).

Moreover, the cerebellum is known to be critically involved in age-related loss of balance and fine motor control, and cerebellar damage (produced by irradiation) is known to yield motor impairment that is relatively selective for tasks such as beam walking, that require concurrent coordination of exteroceptive and proprioceptive information (Yokota, et al 2009).

Hand Grip
The handgrip test measures forelimb strength and coordination. This test was included to screen for neurobehavioral toxicity. In this context, poor performances in grip strength are interpreted as evidence of motor neurotoxicity. Results from present study suggest motor deficits resulting from crude oil-induced neurotoxicity in all test groups.

There is some experimental evidence to suggest that certain individual constituents of the crude oil may exhibit neuro-toxicological properties. For example, mice exposed to a single dose (20 ul) of kerosene by aspiration exhibited drowsiness, lack of coordination, and behavioral changes (Roberts, *et al*, 2011). Similarly, rats exposed to 12 g/kg body weight of deodorized kerosene (Deobase) via oral gavage exhibited unsteady gait and drowsiness (Roberts, *et al*, 2011). Hyperactivity and increased tactile stimuli responses were observed in mice following dermal exposure (100 µl/d × 7 d) to kerosene (Vinet and Sik 2006).

However, the molecular basis for such neurological effects remains unknown, partly due to limited neurotoxicity investigations conducted with such agents or mixtures containing these agents.

Since hydrocarbons are membrane-perturbing substances, it was postulated that petroleum-related aliphatic hydrocarbons and/or anionic surfactant molecules may affect neuronal membranes producing aberrant synaptic signaling and impaired neurotransmission, defects that culminate in neural damage. (Chung *et al*, 2009). This could be the partly responsible for the decline in grip strength and neuro-coordination observed in the test groups.

CONCLUSION

This study reported an over-expression of superoxide dismutase, malondialdehyde, and catalase, following crude oil ingestion by rats. These molecules are biomarkers of oxidative stress. Over-expression of these markers potentially serves as a compensatory mechanism in response to over-production of oxygen radicals. Moreover, we demonstrated significant reduction in glutathione levels manifest of oxidative stress, with consequent cognito motor deficits in all crude oil-treated rats.

The increase in the brain tissue levels of these markers was associated with decline in cognito-motor performance in the experimental animals.

From findings from the present study, the ability of crude oil to induce a significant increase in superoxide dismutase, malondialdehyde, and catalase expression with reduced protein and glutathione makes crude oil and agent of oxidative injury/stress.

Oxidative stress increases lipid peroxidation process and hence degrades membrane lipids of neuronal cells. This effect can hamper signal transfer along neuronal cells. Furthermore, the increase rate of protein denaturation by oxygen radicals is implicated in the Amyloid plaques formation evident in most neurodegenerative diseases.

Also considering the potency of crude oil in decreasing protein synthesis significantly shows that crude oil could impair learning and memory processes since these processes involve the synthesis of new proteins and establishment of new synapses. Findings from the present study indicate long-term intake and exposure to crude oil could cause lead to cognito-motor deficits.

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