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ESTIMATION OF SERUM CHOLINESTERASE ACTIVITY OF OCCUPATIONALLY EXPOSED WORKERS OF A FERTILIZER PLANT

M. A. Shad, M. Aman ullah* and R. Perveen
shadaslam @ yahoo.com
Department of Chemistry, Bahauddin Zakariya University, Multan-60800, Pakistan

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Abstract

In the present study, serum cholinesterase activity was measured in the sera of the workers of fertilizer plant and the people residing in the staff colony. Carbon dioxide, ammonia, nitric acid and phosphoric acid are synthesized for the manufacturing of urea, nitrophos and calcium ammonium nitrate in the fertilizer plant. The activity of the enzyme found to be decreased in the workers and residents who were exposed directly or indirectly to the different gaseous emissions and waste products produced during different chemical processes compared to unexposed subjects. It is therefore suggested that the monitoring of serum cholinesterase activity can serve as a measure of an occupational exposure of workers of the fertilizer plants and can also be used as biomarker to monitor the toxicity of gaseous emissions and waste products.

Keywords: Serum cholinesterase, Occupational exposure, gaseous emissions, Fertilizers

1. Introduction

The fertilizer plant which is used for the manufacturing of nitrogen, phosphate and potassium (NPK) fertilizers poses some chemical and physical risks regarding personal health. The main chemicals which must be considered for occupational health and safety include: 1) acids *i.e* nitric, phosphoric and sulphuric acids 2) gases *i.e* ammonia, nitrogen oxides, compounds containing fluorine, chlorine and sulphur 3) dust (NPK dust is regarded as inert) and 4) hot salt melt (can cause severe burning on contact). Decomposition can also occur when fertilizer or fertilizer slurry containing ammonium nitrate is heated above a certain temperature. Large amounts of toxic gases are given off during the different chemical processes involved in the manufacturing of fertilizers. Special precautions should be taken against these gases because they can cause lung oedema after a long time exposure. Aerosols of NH_4NO_2 and NH_4Cl may be formed during the different production steps of fertilizer.

Health hazards encountered by workers at a granular chemical fertilizer factory in Calgray, Canada were reported in literature (Jasper, 1989). The potential hazards included corrosive materials, noxious gases, nitrate melts, radioactivity, dusts, welding fumes and physical agents such as noise, heat stress and heavy lifting. Some chemicals presented a low potential hazard since there was minimal exposure due to normal operations of the facility. Catalysts used in the manufacturing process were potential hazards to those workers that are removing or installing charges. The noxious gases that could be encountered during the manufacture of fertilizer were HF and H_2S which were evolved during the production of phosphoric acid since phosphate rock contained both fluoride and sulfide.

In past years, there have been some reports (Meng *et al.,* 1995; Meng and Zhang, 1997) from many countries, which showed a significant excess of chromosomal aberrations among workers at phosphate fertilizer factories.

* Department of Statistics, Bahauddin Zakariya University, Multan-60800, Pakistan.

Another report described the occupational hazards of the employees of a phosphate fertilizers plant (Renke *et al.,* 1987). The long-term effects of fluorine influence were found in the persons with longer length of service. It was also reported that phosphate fertilizer industry causes a hazard of exposure to gaseous particulate fluoride and also the other phosphate dust components (Abu Dhaise and Abu Omar, 1998). Ammonia, urea and diammonium phosphate affected the lung functions of workers in a fertilizer plant (Bhat and Ramaswamy, 1993).

Zlatey *et al.,* (1998) studied the influence of harmful factors of the working environment such as: microclimate, dust, noise, vibrations, and chemical noxes like ammonia, nitric oxides, hydrogen fluoride and gaseous fluorides, on the health status of workers involved in the production of fertilizers and ammonia in a nitrogen fertilizer plant. The biochemical monitoring indicated a statistically significant dependence of abnormalities of the biochemical parameters *i.e.* creatinine, urea, ammonia transaminase activity, phosphorus and fluorine on the professional exposure. Disturbances in metabolism, liver function and mineral metabolism in the exposed workers were also reported, which were proved by the enhancement of different biochemical parameters in the serum and urine.

Balizs and Gyocsi (1983) described the effect of flue gas from the combustion of waste oil onto the activity of cholinesterase. The activity of cholinesterase was inhibited in presence of gaseous components (SO_2, CO, CO_2, NO_X) and chloride dissolved in aqueous solution indicating that the enzyme can be used as a biochemical indicator to characterize noxious emissions.

Cholinesterase enzymes are known targets for certain pesticides, including organophosphate and carbamate esters. Two principal types of cholinesterase enzyme have been identified in blood erythrocyte acetylcholinesterase and plasma or serum cholinesterase. The latter is also referred as "pseudo-", "butyryl-" and "non-specific" cholinesterase (Ellenhorn and Barceloux, 1988, Minton and Murray, 1988). The plasma cholinesterase determination has been established as a screening test for low levels of exposure (WHO, 1985, WHO, 1986).

After careful survey of literature, it was observed that no work has been carried to study the effect of hazards of fertilizer industry on cholinesterase, an enzyme vital to the functioning of the central nervous system. We were therefore, prompted to undertake the present investigation to estimate the serum cholinesterase activity of occupationally exposed workers of a fertilizer plant.

2. Material and Method

The study was carried out on 50 male subjects who included a control group of 10 healthy participants with no occupational exposure having same socio-economic status. The 30 workers working at a Fertilizer Plant, Multan, Pakistan (manufacturing urea, nitrophos and calcium ammonium nitrate), were categorized according to their length of service. A group of people residing in the staff colony located in the premises of the fertilizer plant was also included.

Group 1: 8 workers who were working for 1-10 years

Group 2: 5 workers who were working for 11-20 years

Group 3: 17 workers who were working for 21-30 years

Group 4: 10 male residents of the staff colony

This study was approved by the Research and Planner Group, Bahauddin Zakariya University, Multan, Pakistan. The samples were taken over a two week period. All the participants gave consent before the blood samples were taken.

Blood samples (5ml each) were collected from each subject and sera were analyzed for serum cholinesterase activity. The colorimetric method (Knedel and Boetteger,

1967) was used for the measurement of serum cholinesterase activity using a Diagnostic Cholinesteras Kit, Boehringer Mannheim. This method is based upon the hydrolysis of cholinesterase. The reaction between thiocholine and dithiobisnitrobenzoate gives 2-nitro-5-mercaptobenzoate, a yellow compound which can be measured at 405 nm. All the observations were made at 25°C. The enzyme activity was expressed as IU/L. The data were analyzed by a two-tailed Student's t test. p values of <0.05 were considered statistically significant.

3. Results and Discussion

The mean and standard deviation values of control and exposed groups are given in the **Table-1**. The mean and standard deviation values of serum cholinesterase for control were 12130 ± 1950 IU/L and those for exposed groups were 8082 ± 1570 IU/L in group I (1-10 years), 10777 ± 2042 IU/L in group II (11-20 years), 8457 ± 2985 in group III (21-30 years) and 11236 ± 3638 IU/L in group IV (subjects residing in colony). The average values for serum cholinesterase activities of exposed groups were found to be decreased as compared to control.

Table-1 Mean±S.D. values of serum cholinesterase activity in normal and exposed groups.

Groups	Mean ± S.D. Values IU/L	p-Values
Control Group		
Exposed Groups	12130 ± 1950	----
Group I (1-10 years)	8082 ± 1570	$p < 0.001$
Group II (11-20 years)	10777 ± 2042	$p > 0.1$
Group III (21-30 years)	8457 ± 2985	$p < 0.001$
Group IV (Residing in colony)	11236 ± 3638	$p > 0.1$

Values given in the parenthesis indicate the duration of exposure

In group I (75 %) and group III (59 %) workers showed low activity of serum cholinesterase than the normal range. These exposed groups showed mean serum cholinesterase depression of more than 30 per cent, a decrease which was statistically significant ($p < 0.001$) compared to the control average level. While, in group II, 20 % of the workers were affected and no significant decrease was found in activity of the enzyme ($P > 0.01$). All these risk groups of workers were directly exposed to gaseous emissions and other waste products from different chemical processes of fertilizers manufacturing. People residing in the colony (group IV) were less affected than the people working in the fertilizer plant because they were not directly exposed to these anoxic.

Different chemical substances i.e. carbon dioxide, ammonia, nitric acid, and phosphoric acid are synthesized for the manufacturing of urea, nitrophos and calcium ammonium nitrate. HF and H_2S are also evolved during the production of phosphoric acid since phosphate rock contained both of the fluoride and sulfide (Jasper, 1989). The toxic gases and waste products which are produced, during the different chemical processes can cause the depression in the serum cholinesterase activity of the workers who were directly or indirectly exposed to these chemicals substances.

It has been reported that the ammonium salts like ammonium acetate and ammonium chloride, when injected to the rat and added to brain homogenate, decreased the acetyl cholinesterase activity and also inhibited acetyle-cholinesterase in brain homogenate of mice (Kosenko *et al.,* 1994).

Our observations revels that the serum cholinesterase activity was found to be decreased in the workers of the nitrogen fertilizer plant and also in the people residing in the staff colony located in the vicinity of the plant as compared to unexposed subjects. These results are in agreement with those reported in literature (Balizs and Gyocsi, 1983).

It is therefore, suggested that the workers who are working in the fertilizer plant must take precautionary measures to avoid their exposure to the noxious gasses and waste

products of different chemical processes. The monitoring of serum cholinesterase activity can serve as a measure of an occupational exposure of workers of the fertilizer plants and may also be used as biomarker to monitor the toxicity of gaseous emissions and waste products. A coordinated action by authorities, societies and international bodies is needed to limit the number of intoxications and environmental pollution.

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