

**ISTOPATHOLOGICAL CHANGES CAUSED BY THE EXPOSURE OF SUPER
BENZENE ON HAEMATOPOIETIC TISSUES (SPLEEN AND BONE MARROW)
) . IN EXPERIMENTAL RATS (*RATTUS NORVIGICUS***

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ABSTRACT

The present study was carried out to determine the effect of super benzene inhalation and its metabolites on haemopoietic tissues(spleen and bone marrow) on experimental rats. Animals were exposed via inhalation to concentrations of (5 and 10) ppm super benzene for 2 hour/day, 5 days /week for 3 months. Histological studies revealed that spleen of the exposed animals to super benzene, were exposed to 5 ppm showed white pulp atrophy and absence of megakaryocytes in red pulp with blood vessels congestion. In 10 ppm showed extramedullary haemopoiesis, acute splenitis and fibrosis as well as showed increased aggregation of lymphocytes in lymph node, thickness with central artery wall also inflammation of inflammatory cells inside central artery and vasodilatation in central artery in asplenic nodule. While the bone marrow related to the animals exposed to 5 and 10 ppm showed reduced in haemopoietic tissue which partly replaced by adipose tissue.

INTRODUCTION

Benzene, the simplest homologue of the aromatic hydrocarbons, is a planar, cyclic molecule with six carbon atoms arranged in a regular hexagon. The molecular formula for benzene is C_6H_6 . It is a volatile, colourless liquid with a characteristic odour (2). Benzene is used in industry as a volatile solvent and as an intermediate in the production of many chemicals, including ethylbenzene/styrene (used in plastics), cumene, linear alkyl benzene, and maleic anhydride (3,10). Benzene is also present in gasoline as an octane enhancer and anti-knock agent, however, levels of benzene in gasoline have been reduced to below 1% by volume, and found naturally in the environment in very low concentrations (9). Benzene and crude oil and gasoline, including emissions resulting from fuel combustion. Vehicular

emissions constitute the main source of benzene in the environment. (1).The atmosphere and surface water are the major environmental sinks for benzene due to its relatively high vapour pressure, moderate water solubility, and low octanol/water partition coefficient. benzene released into the environment eventually distributes itself into the air (19). Since benzene is classified as a Group 1 carcinogen (carcinogenic to humans)(2).Epidemiological studies report similar toxic effects following exposure to benzene regardless of exposure pathway (inhalation or ingestion).The primary toxicological effects of chronic benzene exposure are on the hematopoietic system, depression of the response of B cells and T cells) in rats of benzene inhalation(14). Reduced numbers of each of B cells in the spleen and bone marrow, T cells in the thymus and spleen (15).The hematologic lesions in the bone marrow can lead to peripheral lymphocytopenia and/or pancytopenia following chronic exposure, these lesions may lead to the development of hematologic damage(13).

MATERIALS AND METHODS

Thirty six male rats (*Rattus norvegicus*) weighing 180-200 gm. were randomly selected from the animal house.They were given standard pellet diet and housed in well ventilated room at control ambient temperature ($25 \pm 5^{\circ}\text{C}$) and natural day light cycle.

These rats were equally divided into 3 groups comprising 12 rats in each group. The first group was control while the second and third groups were exposed in chamber (size 1m^3) to 5 and 10 ppm of super benzene via inhalation for 2 hr/ day, 5 days/week, for 12 weeks respectively.

All the experimental rats after completing 12 weeks experimental period were anaesthetized and their spleen were fixed in 10% buffered formalin for 48 hrs.

Other specimens were taken such as bone marrow isolated from femurs, fixed in acetic acid-zinc-formaline fixative (AZF) for 24hrs, washed in distilled water for 30 min, decalcified in 10% formic acid-5% formaldehyde for 24hrs, then all the specimens were processed to dehydrated, cleared, infiltration, embedded in paraffin wax, sectioned at 5 μm . Thickness stained with hematoxyline - eosin and examined by light microscope (12).

RESULTS

Histologic observations of the spleen related to control rats showed normal structure of white pulp and red pulp (Fig.1). While that of treated animals with super benzene via inhalation at 5 ppm showed atrophy in white pulp and absence of megakaryocytes in red pulp with blood vessels congestion (fig.2, 3).

Also the spleen of the animals exposed to 10 ppm showed atrophic of white pulp and increased of extramedullary haemopoiesis, acute splenitis and fibrosis (fig.4), the results also showed aggregation of lymphocytes in lymph node and increased thickness of central artery wall with infiltration of inflammatory cells inside it and vasodilation in central artery in asplenic nodule (fig. 5).

Observation on bone marrow related to control animals showed active bone marrow in respect of haemopoiesis, showed megakaryocytes and hemocytoblasts (fig. 6) While the bone marrow related to the animals exposed to 5 and 10 ppm showed reduced in haemopoietic tissue which partly replaced by adipose tissue comparative to control animals (fig. 7).

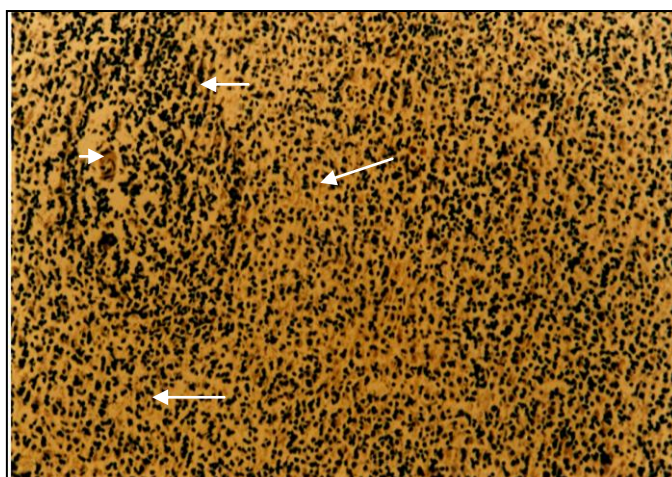


Fig.1: Microphotograph of T.S. of the spleen of the control animals revealed white pulp → and red pulp → and central artery → (H&E 215 X).



Fig.2: Microphotograph of T.S. of spleen of animals exposed to 5 ppm showing atrophic of white pulp → (H&E 535 X)

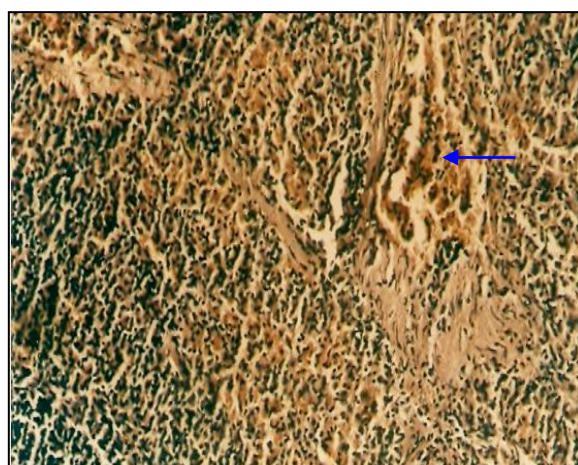


Fig. 3: Microphotograph of T.S. of spleen of animals exposed to 5 ppm showing congestion in blood vessels → (H&E 215 X).

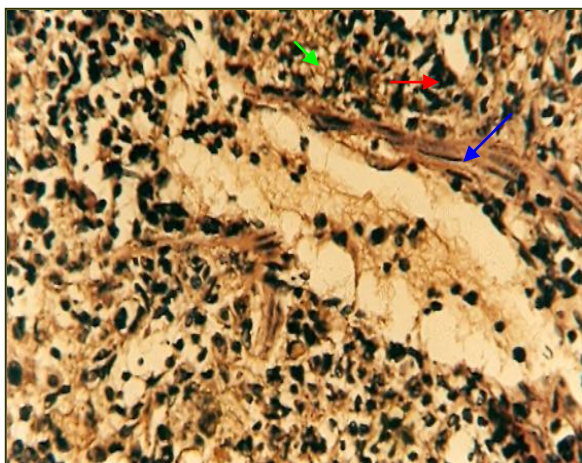


Fig.4: Microphotograph of T.S. of spleen of animals exposed to 10 ppm showing atrophic of white pulp (green arrow) and extramedullary haemopoiesis (red arrow).

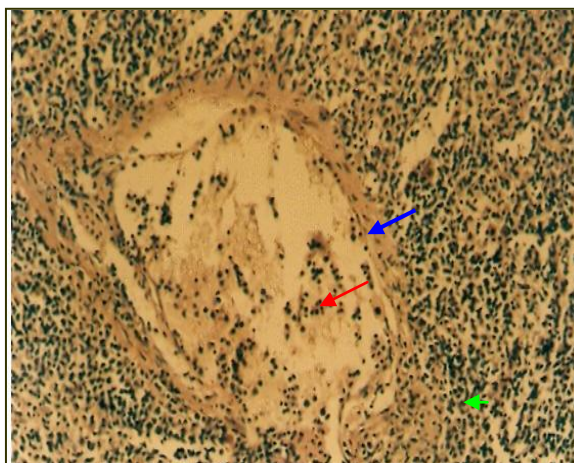


Fig.5: Microphotograph of T.S. of spleen of animals exposed to 10ppm showing aggregations of lymphocytes in lymph node (green arrow) and thickness in central artery wall (blue arrow) with inflammatory cells inside in central artery (red arrow) (H&E 215X).

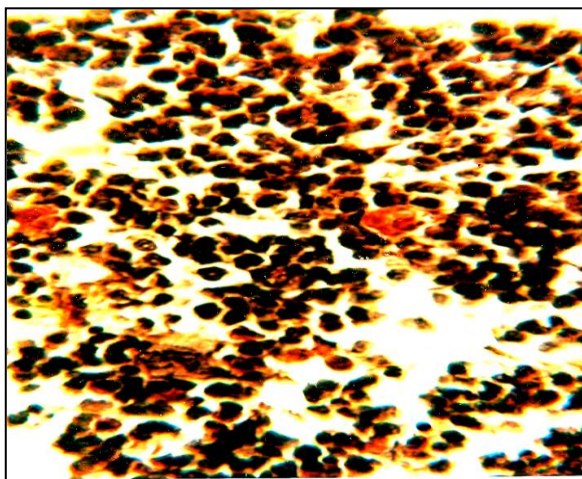


Fig. 6: Microphotograph showed bone marrow of control animals showing megakaryocyte (blue arrow) and hemocytoblast (green arrow) (H&E. 775 X).

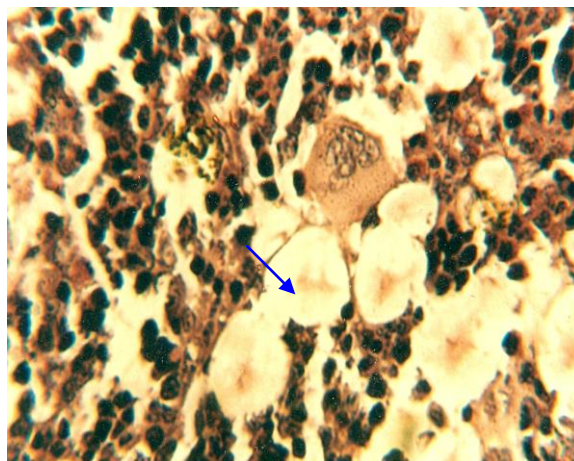


Fig. 7: Microphotograph of bone marrow related to animals exposed to 5 and 10 ppm showing reduced haemopoiesis and bone marrow partly replaced by adipose (blue arrow).

DISCUSSION

Results of this study showed many histopathological changes in hematopoietic tissues (spleen and bone marrow), related to animals exposed to super benzene. Benzene metabolized in the body by cytochromes P450 2E1 to phenol, catechol, and hydroquinone, these metabolites can accumulate in bone marrow and bioactivated by myeloperoxidases and other heme-proteinperoxidases, to reactive semiquinones and quinines, which can further lead to the formation of reactive oxygen species(ROS)(17).The role of ROS initiated toxicity in the hematopoietic tissues (8).In the present study, the aggregation of the lymphocytes inside the lymph node can be considered as a sign of an immune response, since these inflammatory cells play an important role to the toxic metabolites of benzene (5). The results indicated reduced in hemopoiesis of bone marrow this due to benzene and its metabolited very toxic to most cells.The major toxicity observed in experimental animals (mice, rats, and rabbits) has been on the blood- forming cells of the bone marrow, the hemopoietic system.(16).Cronkite et al (4) showed reduced bone marrow cellularity and adecreased number of pluripotent stem cells in bone marrow were exposed male and female mice by benzene inhalation.

In addition, hydroquinone and catechol have been shown to reduce the number of spleen and bone marrow progenitor B - lymphocytes and to inhibit polyclonal plaque - forming cells (21, 22).

Ward et al (20) observed histopathological findings included myeloid hypoplasia, depletion of the periarteriolar lymphoid sheaths in the spleen, lymphoid depletion in the mesenteric lymph nodes, and increased extramedullary haematopoiesis in the spleen, these changes observed in male and female rats and mice exposed to benzene vapour. Benzene and metabolites were concentrated in adipose tissues included bone marrow, sometimes bone marrow cells replaced with adipose tissues and reduction of erythrocytes in blood circulation cuasing aplastc anemia and effects of leucocytes cuasing leukemia (6).

التغيرات النسجية المرضية المتسببة عن التعرض للبنزين المحسن في النسيج المكون للدم (الطحال ونقي العظم) في الجرذان المختبرية *Rattus norvigicus* .

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الخلاصة

تمت دراسة تأثير أستنشاق بخار البنزين المحسن على الانسجة المكونة للدم (الطحال ونقي العظم) والمستخدم حاليا كوقود للسيارات ومولدات التوليد الكهربائية في الجرذان المختبرية. عرضت الحيوانات الى التراكيز (5 و 10) جزء بالمليون من بخار مادة البنزين المحسن وبمعدل 2 ساعة / يوم و 5 يوم/ اسبوع ولمدة 12 اسبوع. اظهرت الدراسة تغيرات نسيجية مرضية في الطحال تشتمل على ضمور اللب الابيض واحتقان للاوعية الدموية اضافة الى ظهور حالة التليف وزيادة في سمك جدار الشريان المركزي مع ارتشاح خلايا دفاعية داخل الشريان الطحالي. كما اظهرت الدراسة نقصان في خلايا الدم الناتج عن خلل وظيفي في نقي العظم مما ادى الى احلال النسيج الدهني بدل الخلايا . أكدت النتائج الحالية على التأثيرات السلبية لبخار هذه المادة من خلال التغيرات المرضية في تركيب نسيج الطحال ونقي العظم .

REFERENCES

1. **Agency for toxic substances and disease registry (ATSDR). (1997).** Toxicological profile for benzene(update). puplic health service U.S. Department of health and human services.Atlanta. GA.
2. **Agency for toxic substances and disease registry (ATSDR). (2005).** Toxicological for benzene(draft for comment Atlanta, GA: U.S. Department of health and human services, puplic health service.
3. **CPI, (2003).** CPI Product Profile for benzene. Camford Information Services Inc., Scarborough, Ontario.
4. **Cronkite, E.P.; Drew, R.T.; Inoue, T. and Bullis, J.E. (1985).** Benzene hematotoxicity and leukemogenesis. Am. J. Ind. Med., 7: 447-456.
5. **Dei, I.; Dobronyi, I. and Varga, L. (1986).** Immuno-neuro and general toxicological animals studies on synthetic pyrethroid, Ecotoxicol. Environ. Saf . 12: 220-232.

6. **Goldstein, B.D. and Witz, M.D. (2000).** Benzene. In: Lippman, M. (ed). Environmental Toxicant (Human exposures and their health effects). John Wiley & Sons, Inc. pp. 121-149.
7. **Gultteridge, J.M. and Halliwell, B. (2002).** Free radicals and antioxidants in the year 2000. Ahistorical look to the future. Ann. Acad. Sci., 899: 136 - 147.
8. **Gultteridge, J.M. and Halliwell, B. (2002).** Free radicals and antioxidants in the year 2000. Ahistorical look to the future. Ann. Acad. Sci., 899: 136 - 147.
9. **Hazardous Substances Database(HSDB) (2003).** National library of Medicine.
10. **Jaques, A.P. (1990).** National inventory of sources and emissions of benzene (1985). Environment Canada (EPS5/AP/1).
11. **Kalf, G.F. (1987).** Recent advances in the metabolism and toxicity of benzene. CRC Crit. Rev. Toxicol., 18: 141- 159.
12. **Naresh, K.N.; Lampert, I.; Hasserjian, R.; Lykidis, D.; Elderfield, K.; Horncastle, D.; Smith, N.; Murray, W. and Stamp G.W.(2006).**Optimal processing of bone marrow trephine biopsy: the Hammersmith Protocol., J. Clin. Path. 903-911.
13. **NTP, National Toxicology Program (1986).** NTP Technical Report on the Toxicology and Carcinogenesis Studies of Benzene (CAS No. 71-43-2) in F344/N Rats and B6C3F1 Mice (Gavage Studies). U.S. Department of Health and Human Services, Public Health Service, National Institutes of Health NIH Publication No. 86-2545.
14. **Ross D. (2000).** The role of metabolism and specific metabolites in benzene – induced toxicity : Evidence and issues. J. Toxicol. Environ. Health. 357-372.
15. **Rozen, M.G.; Snyder, C.A. and Albert, R.E. (1985).** Depressions in B and T-lymphocyte mitogeninduced blastogenesis in mice exposed to low concentration of benzene. Toxicol. Lett. 20: 343-349.
16. **Snyder R.; Wix G.; Goldstein B.D.(1993).** The toxicology of benzene. Environ Health Persp.100-295.
17. **Snyder, R.(2002).** Benzene and leukemia.Crit. Rev. Toxicol. 32: 155 – 210.
18. **Thomas D.J.; Reasor M.J.; Wierda D.(1989).** Macrophage regulation of myelopoiesis is tered by exposure to the benzene metabolite hydroquinone. Toxicol App1 Pharmacol. 440-453.
19. **Wallace, L.A. (1989).** Major sources of benzene exposure. Environ. Health Perspect., 82: 165–169.
20. **Ward CO, Kuna RA, Snyder NK, Alsaker RD, Coate WB, and Craig PH. 1985.** Subchronicinhalation toxicity of benzene in rats and mice. Am. J. Ind. Med. 7:457-473.

21. **WIERDA, D. and IRONS, R.D. (1982).** “Hydroquinone and catechol reduce the frequency of progenitor B-lymphocytes in mouse spleen and bone marrow.” Immunopharmacology 4:41-54. 24-
22. **HSIEH, G.C., PARKER, R.D.R., SHARMA, R.P., and HUGHES, B.J. (1990).** “Subclinical effects of groundwater contaminants. III. Effects of repeated oral exposure on combinations of benzene and toluene on immunologic responses in mice.” Arch. Toxicol. 64:320-328