Research Title:

Justifications of the proposed exposure limit (running annual average) for benzene.

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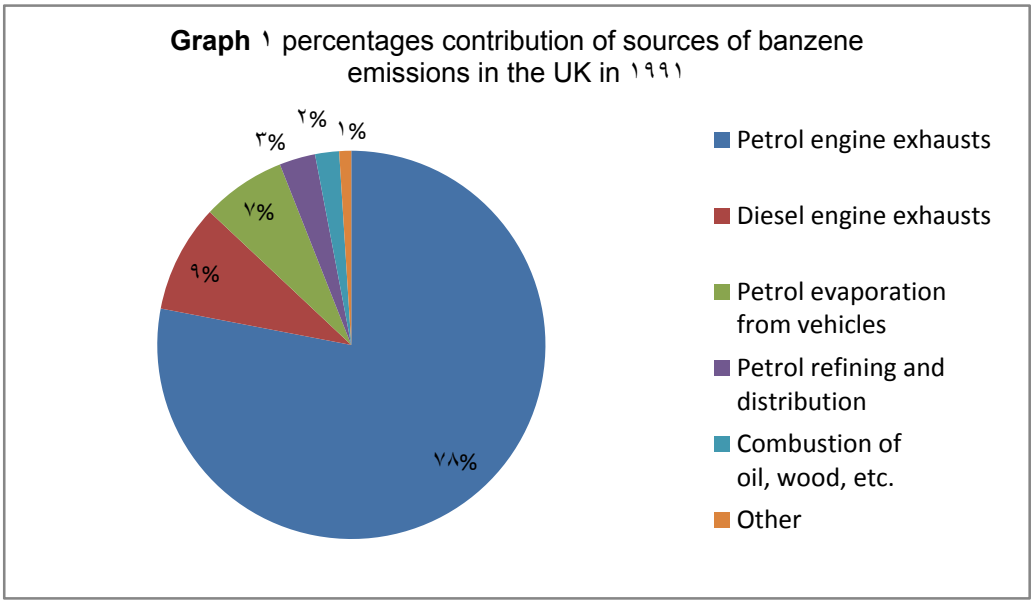
١.٠ Introduction

Benzene is an important compound of organopollutants family which is widely used in gasoline, aviation fuels, and other industrial syntheses (Lee *et al*. ٢٠١١). Benzene often found with other pollutants like Toluene, Ethylbenzene, and Xylenes (collectively known as BTEX) at contaminated places resulting from leakage or accidental spills of fuels, solvents, and chemicals, or improper disposal of waste (Zhang *et al*. ٢٠١٢).

In order to illustrate harmfulness of benzene, natural fate of this compound in the atmosphere, water, soil, sediment and biota must be concerned in order to decide individual exposure limit which has critical health effects of human(Nielsen *et al*.١٩٩١).

٢.٠ Sources of benzene in the UK

According to the Expert Panel on Air Quality Standards (EPAQS), in ١٩٩١, as shown in the graph١, some ٧٨ % of the United Kingdom benzene emissions were from petrol engine exhausts (EPAQS ١٩٩٤).



٣.٠ Environmental fate of benzene

٣.١ Air

In the ambient air, with adequate amount of hydroxyl radical concentration, the life-time of benzene ranges between ٤.٨ to ١٦ days. Consequently, it degrades by reaction with hydroxyl radical through photo-oxidation to produce other oxidation products like phenol, glyoxal, methylglyoxal, nitrobenzene and biacytel (Singh and Zimmerman ١٩٩٢). That is meant that in normal

circumstances benzene can transfer through hundreds or even thousands of kilometers before it degrades to other compound in the atmosphere.

٣.٢ Water

Benzene is soluble in water with about ١٧٨٠mg/l at ٢٥ C^{o}. However, it has the Henrys' Law constant of ٥٥٠ pa.$m^{٣}$ per mole at ٢٥C^{o}, so it has a great tendency to gaseous phase to volatilize into the ambient air from surface water (WHO ١٩٩٣).

Research has been published by Prenafuta-Boldu *et al*. and Zhang *et al*. were agreed that Fungi and Mycobacterium species are able to degrade benzene compounds to use it in the mineralization process or cell walls construction (٢٠٠٠, ٢٠١٢). Under aerobic condition in the surface water, the half-life time of benzene is estimated between ٣٣ hours to ١٦ days (Tabak *et al*.١٩٨١). However, in the groundwater, where condition is anaerobic, bacterial degradation is slow and might extend for ٢٣ to ٧٢٠ days (IEH ١٩٩٩). Moreover, most of the recent literature (Lovely ٢٠٠٠, Weelink *et al*. ٢٠١٠) argued that benzene undergoes hydroxylation under anaerobic condition to phenol that subsequently undergoes ring reduction under methanogenic condition to produce methane and $CO_{٢}$.

٣.٣ Soil

There are three pathways of benzene in the soil: enters the ambient air by volatilization, displaces to the surface water through wash-outs, and or enters the groundwater as a result of leaching (IEH ١٩٩٩). However, still now, there is no scientific parameter to clarify life-time and evaporation rate of benzene in the soil (Nielsen *et al.* ١٩٩١).

٣.٤ Biota and aquatic life

Most of the studies which were carried out on some aquatic biota and fishes suggest that the potentials of benzene on the food-chain are very limited. That is because; benzene has a low bioconcentration factor which causes the accumulated benzene to be cleared from the organisms soon after they left water polluted with benzene (Herman et al ١٩٩١, Park and Lee ١٩٩٣).

٤.٠ The Effects of benzene on human health

A number of studies have been conducted to indicate the potentials of benzene on human and animals. For instance, a significant increase of neoplasm, malignant lymphomas and skin tumors were observed among the tested animals (rats and mice) were dosed with ٥٠,١٠٠,٢٠٠ mg/kg benzene concentration (Dean ١٩٨٥).

Acute toxicity and death was reported among workers inhaled (٢٥٠ – ٢٠ ٠٠٠ ppm) of benzene for a period between minutes to hours (Thienes and Haley ١٩٧٢, Clayton and Clayton ١٩٩٤). While,

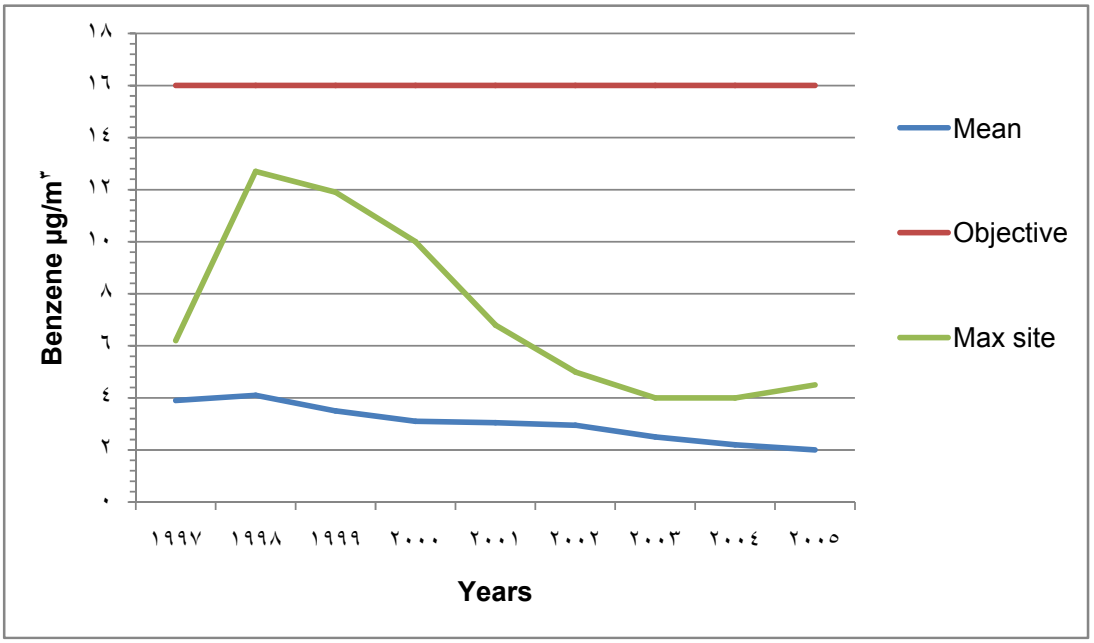
chronic toxicity potentials in form of Hematological, Mutagenic and Carcinogenic health adverse was observed in workers subjected to low and prolong benzene exposure of ١٠-١٠٠ ppm (Yin *et al* ١٩٨٧, Rothman *et al* ١٩٩٦, Hayes *et al*. ١٩٩٧). In addition, Sorahan, Kinlen and Doll's published research (٢٠٠٤) suggest that the examined mortality of carcinogenic effects of benzene exposure of a group of UK workers were limited to acute non-lymphocytic leukemia (ANLL).

Depending upon these studies, the Institute of Environment and Health in the UK agreed that benzene is genotoxic carcinogen and estimated ٢٠ ppm benzene concentration as the lowest observed adverse effect level(LOAEL) which may results in acute non-lymphocytic anemia leukemia in the human(IEH ١٩٩٩).

٥.٠ Existing regulations and current benzene emissions.

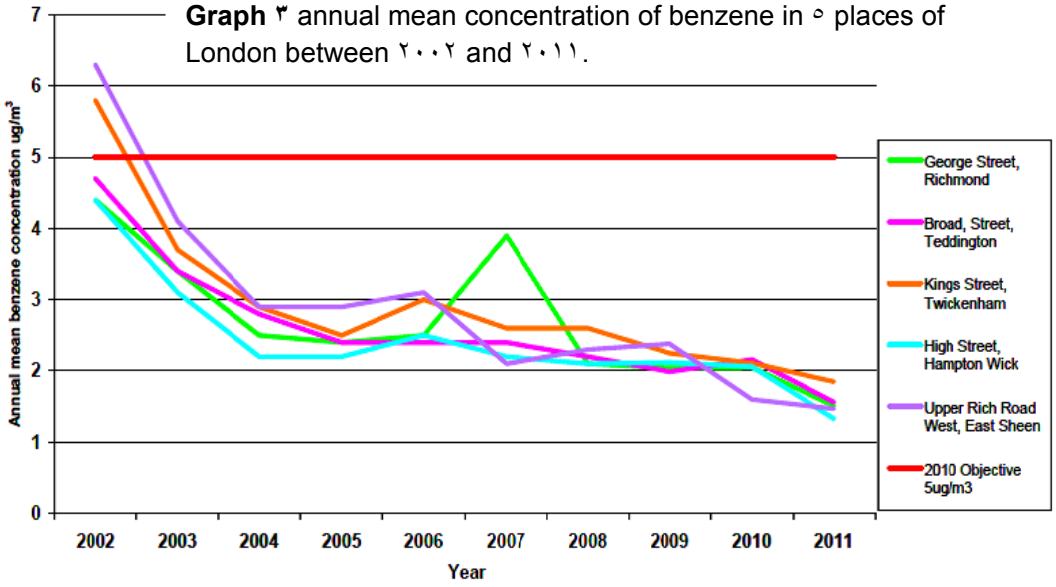
In the EU, the last standard permissible annual mean value of benzene was set at ٥µg/m^{٣} (١.٥٤ ppb) (EU Directive ٢٠٠٨/EC/٥٠, ٢٠٠٨). In the UK, EPQAS (١٩٩٤) recommended ٥ppb as running annual average of air quality standard of benzene with target value of ١ ppb running annual average.

Graph ٢ Annual mean concentrations of benzene in the UK and ٢٠٠٣ Air Quality Strategy objective.



Moreover, according to the Air Quality Strategy of benzene in the UK, the objectives were ١٦.٢٥µg/m^{٣}(٥ ppb) and ٥µg/m^{٣}(١.٥٤ ppb) that had to be met by the end of ٢٠٠٣ and ٢٠١٠ respectively (Defra ٢٠٠٧).

Nevertheless, latest published reports suggest that current emissions of benzene in the UK are below the standard limits of ٥ ppb and ١.٥ ppb (.Air Quality Strategy Report ٢٠٠٧, The London Wide Environment Program ٢٠٠٩).



Graph ٣ annual mean concentration of benzene in ٥ places of London between ٢٠٠٢ and ٢٠١١.

٦.٠ Conclusion

Benzene is an important industrial hydrocarbon compound which might cause many carcinogenic and neurotoxic problems for the human being. Its health problems have been estimated on the bases of occupational and environmental exposure problems studied on the laboratory animals which are too difficult to be used as bases to conclude effects on the human being, or drawn from studies on men at specific workplace condition which is also difficult to be generalized on general population that might contain elderly people, children, and pregnant women.

Furthermore, as benzene is genotoxic carcinogen; therefore it is difficult to indicate its safe exposure limit for human being. Fortunately, the suggested standard limit (١ppb) had been considered many safety factors for estimating the running annual mean concentration of benzene, which makes this value acceptable and lower than minimum probable exposure limits that might cause any health problem for the human being.

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