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A Novel and Simpler Approach for Ranking of Indoor Air Pollutants

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Abstract:*The Urban Indoor Air Quality is one of the major environmental health concerns in the global scenario, with the indoor pollution levels higher in both private and public indoor spaces than outdoors, in addition to contribution from outdoor sources. As there are about more than hundred Indoor Air Chemical pollutants, the availability of data on exposures, their toxicity levels and associated health risks is extremely variable, thereby making the ranking process highly cumbersome. The situation hence warrants a ranking of indoor chemicals, which is easy to comprehend and adapt as well. In the present study, the research envisages five sequential steps sensitizing priority wise classification to develop the final ranking. The methodology included frequency assessment in terms of source prevalence, frequency of emissions, health impacts, and risk-based concentration versus existing Indoor Air Quality standards and carcinogenicity classification*.

Keywords: *Indoor; Air; Quality; Pollutants; Ranking*

I. Introduction

Although outdoor air pollution is much talked about, attention towards indoor air pollution continues to remain sparse. Most people spend more than 90% of their time between the four walls. During this period of exposure, the nature of the enclosed environment directly affects the health and productivity of the occupants [1]. The modern construction practices have advanced much beyond the traditional building materials, and now incorporates extensive of chemically synthetized materials, inclusive of other basic day to day human needs and fugitive outdoor sources [2]. Unfortunately with the passing of time, and due to factors such as ventilation, amount of usage, and maintenance, these accessories outgas toxic fumes containing a staggering variety of chemicals1. The intensity of these indoors has been made worse due to energy efficient measures thereby reducing ventilation rates and raising exposure levels [3]. High pollutant concentrations can remain in the air for long periods after certain activities or from the use of cleaning Chemicals [4]. The ‘Sick Building Syndrome’ phenomenon often linked to ‘the acute incidence of indoor air Pollution can occur in closed or poorly ventilated offices and residences’. In contrast, "building related illness" is a phenomenon when symptoms of diagnosable illness are identified and directly attributed to airborne contaminant [5]. The intensity of aforementioned phenomenon can be checked only if the contributing agents and pollutants are properly diagnosed. However there is inadequacy in the standards due to special variable character of indoor spaces. The air quality guidelines published by the World Health Organization (W.H.O.), is intended to be also applicable for indoor air [6]. This hinders the development of an efficient ranking system.

II. Literature Review

The research conducted on ranking indoor air pollutants is highly sparse. The Office of Radiation and Indoor Air (U.S. Environmental Protection Agency) had developed a screening-level, cancer risk-based ranking analysis, utilizing available monitored data for only 112 chemicals. The dependability of this method was entirely dependent upon reliability of the underlying data for both exposure and risk based concentrations. Data were available that would permit estimation of a rank value for only 59 of more than 1000 potential indoor air pollutants4. Also the ranking analysis was subjective to individual chemicals and did not include radon, inorganic chemicals, and only addressed inhalation exposures. This ranking was useful only as a relative ranking, since given the full data there would be various other chemicals that would probably rank higher [7]. Ayoko, G. A. et al (2005) obtained Multi-criteria ranking of indoor air quality for non-industrial environments by applying PROMETHEE and GAIA to the data, so as to rank the dwellings on basis of 40 indoor air quality-influencing variables [8]. However this study also was subjective as it was restricted to poly-aromatic hydrocarbons (PAH’s) in indoor environments. The present study attempts to overcome these lacunae.

III. Research Methodology

Presumably, an ideal ranking technique would rank highest those pollutants whose abatement would produce the greatest benefit. In the present study, the research envisages five sequential criterions focusing on priority wise classification to develop the final ranking. Primarily, from an exhaustive literature survey, all the potential sources contributing to indoor air pollution were identified. Secondly, all the toxic indoor air pollutants were extracted from databases of E.P.A. and W.H.O.In the next step, frequency assessment was carried out for sources and pollutants based on emission and occurrence. The list was then prepared for subsequent stages of assessment. The database was then subjected to analysis, in terms of severity and frequency of health impacts. The previous two rankings were individually subjected to weightages (30% and 70% for rankings of 1stand 2ndassessment respectively) and reassessed for New Ranking. This was further compared with Carcinogenicity Index and Indoor Air Quality Standards. Finally the ranking was arrived at with the top spot grabbed by a chemical that posed the greatest threat to human health, in the least concentration and least frequency.

IV. Results and Discussion

The literature hunt revealed Asbestos, Radon, Lead, Formaldehyde, Cadmium, Naphthalene, Benzene, Carbon monoxide, environmental tobacco smoke etc. as among the most referred to chemical indoor air pollutants [9]. The sources most quoted included New Carpeting, Hair spray, New Automobile Interior, plywood, fiberboard, Poorly ventilated meeting rooms, Oil based paint, Perfume/Deodorants, Particleboard, Printed Materials, Gas Engine exhaust, Nail polish Remover, Stationery, Toys, Rest room Deodorizers, Phenolic Disinfectants, Fabrics, Cigarette smoke, repellent & Insecticides [9].

Pollutant	Ranking as per Present Research	Ranking as per E.P.A.	Classification as per Carcinogenicity	I.A.Q. Standards [1]
Benzene	01	15	Class A	10μg/m^3 (Annual Average)
Acetone	02	-na-	-na-	5.9 mg/m^3(24 hours)
Formaldehyde	03	02	Class B1	54 μg/m^3 (24 hours)
Poly vinyl Chloride	04	-na-	Class A	28 μg/m^3 (24 hours)
Toluene	05	26	Class B2	410 μg/m^3 (Annual Average)
Cadmium	06	-na-	Class B1	0.003 mg/l
Carbon Monoxide	07	-na-	Class A	1 hour - 35 mg/m^3
Polychlorinated Biphenyls	08	-na-	Class B2	0.3 μg/m^3
Oxides of Nitrogen	09	-na-	Class A	62 μg/m^3 (Annual Average)
Tetra Chloro Ethylene	10	12	Class B1	0.27 mg/m^3(Annual Average)
Lead	11	-na-	Class B2	0.5 μg/m^3 (Annual Average)
Methane	12	-na-	-na-	-na-
Asbestos	13	-na-	Class A	-na-
Carbon Tetrachloride	14	10	Class B2	0.004 mg/l
Naphthalene	15	24	Class B2	0.01 mg/m^3 (Annual Average)
Radon	16	-na-	Class A	0.6×10^{-5} per Bq/m^3
n-Hexanol	18	21	-na-	-na-

Table I. Ranking of Indoor Air Pollutants

Based on the frequency assessment for sources and pollutants based on emission and occurrence, Formaldehyde was ranked top as the most fatal among the other listed pollutants. In the next separate frequency assessment for severity and frequency of health impacts, Benzene, Acetone and Formaldehyde, were ranked top as the most fatal among the other listed pollutants. When weightage analysis was carried out Acetone, Formaldehyde, P.V.C., Benzene, were ranked top as most fatal among the other listed pollutants. This when further compared with Carcinogenicity Index, Benzene, Acetone and Formaldehyde were ranked top as most fatal among the other listed pollutants. In this manner, the issue of chemicals positioned alike was resolved. The results are shown in Table 1 and compared with the Indoor Air Quality (I.A.Q.) standards and the only other existing ranking by E.P.A.

Benzene was ranked by E.P.A. as low as 15, while present technique ranked it as high as 1. The same can be justified from the fact that it is a Class A Carcinogen and its I.A.Q. standard is extremely fragile when compared to rest of the chemicals on the list. When compared to the E.P.A. ranking which places bothNaphthalene and Toluene on close ranks, the present technique ranks Naphthalene far lower than Toluene. This can be justified from the fact that Toluenenot only contributes to more diseases than Naphthalene, but also its I.A.Q. standard is more sensitive than that of Naphthalene. In another case of disparity, it may be observed that E.P.A. had ranked Tetra Chloro Ethylene lower to Carbon Tetrachloride (CCl_4). However present system found it to be other ways, and can easily defend the findings from the fact that Tetra Chloro Ethylene is a Class B1 carcinogen, while Carbon Tetrachloride is Class B2.

Similar argument holds well in case of other pollutants too. Hence it’s obvious that the resultant ranking of present study holds edge over previous technique, for reasons such as it also considered all indoor environments and sources which were ignored in other techniques. Even the uncertainties in risk-based concentration that had overshadowed the other techniques have been dealt with in the present study as multiple prioritizations were considered. However the limitations that can be highlighted for this technique is the lack of sufficient toxicological testing. The study is highly depended on secondary data and it’s highly probable that the ranking analysis does not include certain chemicals found in indoor air.

But in this context it needs to be noted that this analysis though allows for a relative ranking, has encompassed all major pollutants highlighted in literatures, E.P.A. and W.H.O. Also the method makes no estimate of the potential population exposures or the frequency or duration of exposure, but in defense, it can be substantiated that the present ranking technique was targeted at extracting pollutants prevalent in generalized indoor environment and was also subjective to I.A.Q. standards which have been formulated to above criterions. Also this ranking study targets only individual chemicals and doesn’t not focus on synergistic effect.

V. Summary

When compared with outdoor environment and outdoor pollutants, the indoor pollutants are not easily dispersed or diluted thereby resulting in higher built-up concentrations indoors than outdoors. Under this dire situation, there also exists no credible or substantial data on standards and as well ranking of indoor air pollutants, as a measure to tackle hazards with priority based classification. The present study, which was an attempt to overcome this gap in the literature, has revealed Benzene, Acetone and Formaldehyde as to be ranked most fatal among the listed pollutants. The new ranking was found to better placed with I.A.Q. standards and Carcinogenicity Indices. The technique thereby enables risk reduction efforts on the greatest opportunities for reducing risks through voluntary, non-regulatory risk management approaches. This approach hence offers a useful tool that could facilitate the identification of environments requiring attention, and assist the formulation and prioritization of control strategies.

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