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# Air Quality Assessment of Some Selected Hospitals within Baghdad City

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***Abstract***- *Hospitals are institutions designed to provide medical assistance to sick people have harm to their bodies, making them more likely to die than others, so indoor air quality (IAQ) of the various facilities of the hospital must be taken into account by providing an efficient Heating, ventilating and air-conditioning (HVAC) systems with periodic maintenance and renewal for nonworking parts, and should appropriate with the health status of admissions, workers and visitors, the present study has been carried out to evaluate indoor air quality (IAQ) for three selected hospitals within Baghdad city. The study period included the summer and winter of (2017) and the pollutants considered are Ozone (O3), Nitrogen dioxide (NO2), Fine particles (PM10), Carbon monoxide (CO), Sulfur dioxide (SO2) and Total volatile organic compounds (TVOCs). In addition to examining the airborne microorganisms by determination, both total count and diversity. The main objective of this paper is to assess the (IAQ) inside the hospital environment.*

***Keywords***- *HVAC, TVOCs, IAQ, Microorganisms, Hospital. pollutants*

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## 1. Introduction

Indoor air quality (IAQ) is the most important health and economic issues [1] because most of our time spent inside buildings, schools, homes, hospitals, work places and malls. The means of person air consumption 15kg of air a day by breathing while 1 Kg of food and 2-3 Kg of water [2], so good air quality play an important role in health [3], many epidemiological studies deals with air pollutions and ascending morbidity and mortality outcomes [4, 5], is often rated as the most important environmental issue within the community [6]. Although the air quality importance but there are no clear guidelines available for buildings because its effected by many internal and external factors, hospitals still apart of ecosystem and any changes occur within ambient air will reflect on hospital environment and any air pollution is mostly related to the contamination of urban air by vehicles exhausts and industrial emissions [7-9]. Poor building ventilations causes sick hospital syndrome (SHS), the most important pollutants inside hospitals environment are carbon monoxide (CO), nitrogen dioxide (NO2), formaldehyde (CH2O), total volatile organic compounds (TVOCs), radon, ozone (O3), respirable suspended particulates (RSP) and total viable count of bacteria which can causes health problems with different degrees of intensity, ranging from simple illness to intractable diseases for both work staff, patients and visitors [10-14]. This study aimed to assessed (IAQ) of three hospitals, Public teaching hospital (PTH), privet hospital (PH) and public specialized hospital (PSH) ) within Baghdad city by measuring several parameters such as carbon monoxide (CO), nitrogen dioxide ($NO_2$), Sulfur dioxide ($SO_2$), Ozone ($O_3$), Total volatile organic compounds (TVOCs) and Fine particles as (PM10) beside total count and variety of airborne microorganisms.

## 2. Materials and Methods

### *I. Air Pollutants Concentrations*

Air detectors from the Air Lab at the Environmental Research Center, University of Technology were used to measure the concentration and distribution of pollutants within different locations of three hospitals, (G460 six gases analyzer Germany) was used to measure (CO, NO2, SO2) as well as, (GfG, G460 multi gases detector, Germany) was used to measure (O3 and TVOCs), however fine particulates determined by using (Met One Airocet 531 USA). The readings were recorded in the warm and cold seasons of 2017 by short measuring technique (15 min/ reading).

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II. *Total Count and Diversity of Microorganisms*

Open plate method was employed to collect air samples, standard Petri dishes with Sabouraud Dextrose Agar (SDA) provided by 10µg/ mL amoxicillin utilized to collect fungi samples, while bacterial isolates were collected in the same technique with Brain Heart infusion Agar as a growth medium, all plates exposed for 15 minutes for indoor hospital air, at a height of 150cm from ground level, then all exposed plates were transported to lab by cool clean container on the same day. [15,16].

The fungal samples incubated at 28ºC for 7-10 days, the grown colonies were identified depending on morphological properties (shape, size, color, elevate and edge shape), as well as microscopic examination at (40X) carried out to identified their proliferative parts, conidia shape, size, situation and mycelium segmentation. The plates which prepared to isolate bacteria incubated at 37ºC for 24 hrs., then Gram stain technique applied to study dye pattern, cells shape and bacterial aggregations [17-19].

## 3. Results and Discussion

According to American Society of Heating, Refrigerating and Air-Conditioning Engineers, (ASHRAE) can be defined acceptable (IAQ) as" air in which there are no known contaminants at harmful concentrations as determined by cognizant authorities and with which a substantial majority (80% or more) of the people exposed do not express dissatisfaction".

From the results shown in Table 1, Six variables were studied in the cool and warm season of 2017 in three different hospitals (PTH, PSH and PH), Located in different places of Baghdad city with six different wards of each hospital, the first variable was carbon monoxide (CO) is odorless toxic gas resulting from incomplete combustion of fossil fuels, is related to elevate of heart disease in all ages, increasing 3.68% and 2.3% when the emission rises 1 ppm in 1-hour maximum and 8-hour maximum CO respectively. There is a strong association between CO and NO2 pollutants, seems both of them have significant role in increase respiratory infection in 0-14 years old [20, 21], and cardiovascular disease in elderly because CO can be attached with hemoglobin molecule and reduce its efficiency in the transport of oxygen, from Table 1 can observe that CO concentration symmetrical in the three hospitals without insignificant differences among them, the highest reading recorded in the surrounded area of (PTH) 0.87µg/m3 in the cool season. Generally, (PSH) wards recorded highest readings in both cool and warm seasons this may be due to its location within traffic area or due to its small extent and rapprochement of its buildings and affected its wards by the waste of incinerator. The other element is considered as air pollutant is $NO_2$, from findings in Table 1 can be shown its values dropped in the cold season in all hospitals, but its levels in PSH were higher than from others, this may be due to the location of the hospital or its small size and affected by emission of the incinerator, virtually, $NO_2$ consists naturally from bacterial activities or from volcanic vapor, while man-made comes from fuel combustion or from welding processes, and the use of explosives [22]. Nitrogen dioxide $NO_2$, its health effects can be summarized as one of the causes of upper and lower respiratory disorders in addition to 5-7% of lung cancer result from atmosphere contamination with $NO_2$ and there are epidemiological studies refers to a good association between $NO_2$ and $SO_2$ in most health care admissions respiratory infections and in all age groups [23,24], $SO_2$ is one of air polluting criteria, natural sources of $SO_2$ are volcanoes, forest fire, while man-made sources from transportation system and oil burning [23], $SO_2$ has potential health effects include inflammation of the respiratory tract, reduce the breathing depth in addition to eye irritation and there is good evidence increase $SO_2$ concentration for 10 ppb causes increased in risk of death to 0.2-2% [25], from our study the results diagnosed a slightly increase in the values of $SO_2$ in the PSH due to for the reasons mentioned above. The other health and environment important factor are $O_3$, ozone is toxic odorless and colorless gas may be cause rapid death in high concentrations, in otherwise small increases cause breathing difficulties, chest pain, destroyed the mucus membrane and decreased breathing efficiency [26], ozone formed naturally by photocatalytic at ground level. From findings all $O_3$ measures were less than the reference value (100µg/ $m^3$) [27], most of the readings recorded zero value in the three hospitals but generally, its values in the surrounded area and external parts of the hospitals were higher than other wards this explains the role of ultra-violate ray in its formation. Besides the above important factors, the study discussed VOCs concentrations in each hospital, many people suffering from symptoms related with irritation of the skin and mucous membrane, eyes itching, head each and fatigue, the cause of these symptoms belongs to their exposure to VOC [28,29]. Volatile organic compounds are emitted from different materials like paints, glues, carpets, solvents detergents and disinfectants and also emitted from wood, plastic and rubber materials, in previous

studies more than 100 VOCs were measured included alkanes and alkenes inside hospitals [30, 31], in the present study total VOCs was detected within outdoor and indoor environments, from results the TVOCs exceeded the reference value (500 µg/m3) in operating rooms of each hospital this may be due to heavy uses of detergent and it is noticeable that TVOCs concentration in operating room of private hospital was greater than other similar wards in other hospitals 5200 µg/m3 this may be due to excessive use of disinfectants or because of poor ventilation systems.

**Table 1: Pollutants distribution inside three selected hospitals**

| Parameters (PTH) | Consultancy clinic µ/m$^3$ | waiting hall µ/m$^3$ | Operation room µ/m$^3$ | Bed rooms µ/m$^3$ | courtyards µ/m$^3$ | Outdoor Data µ/m$^3$ | Consultancy clinic µ/m$^3$ | waiting hall µ/m$^3$ | Operation room µ/m$^3$ | Bed rooms µ/m$^3$ | courtyards µ/m$^3$ | Outdoor data µ/m$^3$ | Standards WHO µ/m$^3$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Summer** | | | | | | | **Winter** | | | | | | |
| CO | 0.28 | 0.24 | 0.21 | 0.22 | 0.42 | 0.608 | 0.11 | 0.12 | 0.1 | 0.16 | 0.36 | 0.87 | 41 |
| NO2 | 0.003 | 0.012 | 0.06 | 0.01 | 0.035 | 0.0859 | 0.002 | 0.01 | 0.049 | 0.01 | 0.022 | 0.082 | 40 |
| SO2 | 0.015 | 0.015 | 0.035 | 0.025 | 0.042 | 0.092 | 0.012 | 0.013 | 0.023 | 0.015 | 0.031 | 0.082 | 20 |
| TVOC | 434 | 279 | 4500 | 450 | 140 | 200 | 340 | 200 | 4000 | 300 | 120 | 420 | 500 |
| O3 | 0.01 | 0.009 | 0.02 | 0.01 | 0.034 | 0.096 | 0.0 | 0.0 | 0.0 | 0.0 | 0.045 | 0.09 | 100 |
| PM10 | 0.023 | 0.021 | 0.0 | 0.01 | 0.25 | 0.266 | 0.0 | 0.01 | 0.0 | 0.0 | 0.015 | 0.182 | 150 |
| Parameters (PSH) | Consultancy clinic µ/m$^3$ | waiting hall µ/m$^3$ | Operation room µ/m$^3$ | Bed rooms µ/m$^3$ | courtyards µ/m$^3$ | Outdoor data µ/m$^3$ | Consultancy clinic µ/m$^3$ | waiting hall µ/m$^3$ | Operation room µ/m$^3$ | Bed rooms µ/m$^3$ | courtyards µ/m$^3$ | Outdoor data µ/m$^3$ | Standards WHO µ/m$^3$ |
| **Summer** | | | | | | | **Winter** | | | | | | |
| CO | 0.24 | 0.22 | 0.22 | 0.22 | 0.44 | 0.702 | 0.22 | 0.14 | 0.12 | 0.18 | 0.38 | 0.661 | 41 |
| NO2 | 0.005 | 0.021 | 0.077 | 0.011 | 0.028 | 0.088 | 0.006 | 0.01 | 0.051 | 0.009 | 0.031 | 0.077 | 40 |
| SO2 | 0.025 | 0.018 | 0.037 | 0.028 | 0.055 | 0.097 | 0.015 | 0.016 | 0.028 | 0.024 | 0.039 | 0.088 | 20 |
| TVOC | 450 | 312 | 3800 | 330 | 220 | 560 | 370 | 280 | 2700 | 270 | 120 | 520 | 500 |
| O3 | 0.01 | 0.006 | 0.001 | 0.001 | 0.002 | 0.03 | 0.009 | 0.0 | 0.0 | 0.0 | 0.001 | 0.001 | 100 |
| PM10 | 0.1 | 0.15 | 0.0 | 0.01 | 0. 23 | 0.32 | 0.08 | 0.07 | 0.01 | 0.01 | 0. 12 | 0.166 | 150 |
| Parameters (PH) | Consultancy clinic µ/m3 | waiting hall µ/m3 | Operation room µ/m3 | Bed rooms µ/m3 | courtyards µ/m3 | Outdoor | Consultancy clinic µ/m3 | waiting hall µ/m3 | Operation room µ/m3 | Bed rooms µ/m3 | courtyards µ/m3 | Outdoor | Standards WHO µ/m3 |
| **Summer** | | | | | | | **Winter** | | | | | | |
| CO | 0.25 | 0.14 | 0.22 | 0.11 | 0.38 | 0.662 | 0.12 | 0.18 | 0.13 | 0.16 | 0.28 | 0.454 | 41 |
| NO2 | 0.002 | 0.011 | 0.08 | 0.04 | 0.08 | 0.086 | 0.002 | 0.012 | 0.056 | 0.01 | 0.05 | 0.077 | 40 |
| SO2 | 0.017 | 0.012 | 0.032 | 0.015 | 0.046 | 0.1 | 0.01 | 0.011 | 0.021 | 0.011 | 0.04 | 0.088 | 20 |
| TVOC | 520 | 333 | 5200 | 680 | 240 | 210 | 442 | 320 | 4800 | 620 | 120 | 200 | 500 |
| O3 | 0.00 | 0.001 | 0.00 | 0.00 | 0.01 | 0.01 | 0.0 | 0.0 | 0.0 | 0.0 | 0.01 | 0.01 | 100 |
| PM10 | 0.22 | 0.12 | 0.0 | 0.001 | 0.041 | 0.270 | 0.0 | 0.01 | 0.0 | 0.0 | 0. 15 | 0.177 | 150 |

The current article refers to microbial contamination in all wards of selected hospitals including Consultancy clinic, waiting halls, operation rooms, bed rooms, courtyards and even surrounded area, all these wards reviled high contamination rate of varies genus and species of bacteria and fungi, so this explain increasing the fungal incidence disease in the hospital environments especially among immunosuppressed patient [32], so microbial survey within hospital environment plays vital role to assess hygiene facts of our local health care centers and try to reduce healthcare-associated infections (HAI) rates by detecting the fact of microbial contamination and to assist officials of the Ministry of Health to lay out appropriate mitigation measures to reduce microbial contamination associated health problems. In this study, many bacterial and fungi isolates were identified such as *E Coli, Pseudomonas areuginosa* as Gram-negative bacteria and *Staphylococcus epidermidis Streptococcus sp*. Gram-positive bacteria appeared in all hospitals environment. The most frequent bacterial populations from indoor were *P. areuginosa* (88%), *E coli* (70.5 %) and *Enterobacter sp*. (37%) respectively. It was observed that the frequency of Gram-negative bacteria was greater than that of Gram positive bacteria, this may due to the tendency of Gram-negative bacteria to live and grow in the indoors rather than the outdoors environments, or possessing Gram-negative bacteria some survival strategies like rapid growth rate, mobile organs make it more appropriate to grow and live better in the indoor medium [33,34]. In the case of fungi can be easily observed superiority of *Aspergillus spp.*, then *Penicillium spp*, finally *Mucor spp*. These results agreed with results for previous studies that found the *Aspergillus*, and *Penicillium* major genera in Iraqi hospitals [35]. Also can be noted that fungal contamination increase in the hospital surrounded

environment (outdoor) and in the external wards like consultancy clinics, waiting for halls and courtyards this confirm the free-living nature of fungi and its presence which is invigorating with people and vehicles movement because most of the reproductive parts are airborne. These fungi species stimulate inside hospital wards because of bad ventilation system or availability of required moisture.

**Table 2: Microbial distribution within facilities of selected hospitals**

| Hospital | Total plates | Positive | Percent % | negative | Percent % | Consultancy clinic Growth% | waiting hall Growth% | Operation room Growth% | Bed rooms Growth% | courtyards Growth% | Outdoor |
|---|---|---|---|---|---|---|---|---|---|---|---|
| PTH | 60 | 35 | 58 | 25 | 42 | 98 | 100 | 20 | 35 | 70 | 100 |
| PSH | 48 | 22 | 46 | 26 | 54 | 75 | 66 | 12 | 15 | 78 | 90 |
| PH | 48 | 30 | 64 | 16 | 33 | 100 | 100 | 35 | 45 | 66 | 87 |

**Table 3: Microbial diversity within selected hospitals**

| Microbes | PTH | | PSH | | PH | |
|---|---|---|---|---|---|---|
| | Number | Percentage % | Number | Percentage % | Number | Percentage % |
| *E.coli* | 12 | 70.5 | 1 | 12.5 | 6 | 50 |
| *Enterobacter SP.* | 6 | 35 | 2 | 25 | 2 | 16.6 |
| *Klebsilla SP* | 7 | 41 | 0.0 | 0.0 | 1 | 8.3 |
| *Pseudomonas areuginosa* | 15 | 88 | 3 | 37.5 | 6 | 50 |
| *Proteus mirabilis* | 2 | 11.8 | 1 | 12.5 | 0.0 | 0.0 |
| *Proteus vulgaris* | 5 | 29.4 | 0.0 | 0.0 | 0.0 | 0.0 |
| *Serratia marsecence* | 6 | 35 | 1 | 12.5 | 2 | 16.6 |
| *Staphylococcus aureus* | 8 | 47 | 2 | 25 | 3 | 25 |
| *Staphylococcus epidermidis* | 4 | 23.5 | 1 | 12.5 | 0.0 | 0.0 |
| *Streptococcus sp.* | 2 | 11.8 | 1 | 12.5 | 1 | 8.3 |
| *Bacillus cereus* | 5 | 29.4 | 3 | 37.5 | 3 | 25 |
| *Bacillus subtilis* | 4 | 23.5 | 0.0 | 0.0 | 1 | 8.3 |
| *Streptococcus sp.* | 8 | 47.0 | 2 | 25 | 0.0 | 0.0 |
| *Aspergillus spp.* | 12 | 66.6 | 9 | 64 | 10 | 55.5 |
| *Penicillium,spp.* | 8 | 44 | 5 | 35.7 | 5 | 27.7 |
| *Alternaria spp.* | 3 | 16.6 | 2 | 14 | 0.0 | 0.0 |
| *Mucor spp.* | 5 | 27.7 | 0.0 | 0.0 | 2 | 11 |
| *Chrysosporium spp.* | 1 | 5.5 | 0.0 | 0.0 | 4 | 22 |
| *Yeast species* | 7 | 38.8 | 4 | 28.5 | 9 | 50 |

## 4. Conclusions

In fact, the findings of the current study are agree with the results of many previous studies that the (IAQ) of hospitals is significantly affected by the surrounding environment measurement and can we say that privet hospitals (PH) gave high values for most of the parameters, and the warm season causes elevate of these readings.

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