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Research Article

Indoor Air Quality in Hospitals: The Case of Kastamonu-**Turkey**

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Abstract: People have been spending their days indoors and the air quality of these areas directly affects the health and performance in living urban areas. Especially in public places, the amount of oxygen decreases due to human respiration in the cramped and slightly ventilated environment. The various health problems occur because of the decrease of indoor air quality (IAQ). Fatigue, difficulty in detection, drowsiness and continuity are usually seen in people. This is an issue, which should be primarily investigated in hospitals. Because the patients and caregivers in the healthcare facility are directly affected by the low air quality in the health institutions. People who are coming or working in hospital for treatment have weak and quite higher risk factor. In this context, the indoor air quality has been investigated particulate matter (PM) and CO_2 which is the most important pollutants in terms of human health in some hospitals in Kastamonu. As a result of the study, it is found that IAQ is not enough compared to air quality studies in the areas where hospitals are located, but it is generally not at a level that can threaten health in hospitals. It has also been determined that CO_2 is much lower than other public facilities (school, shopping center etc.).

Key words: Indoor air quality, particulate matter, CO₂, hospitals, Kastamonu.



INTRODUCTION

In 2000, while 47% of the world's population (2.9 billion people) lived in urban areas, by 2030 60% of the world's population is expected to live in cities¹. In European countries, over two-thirds of the total population lives in urban areas. According to the Turkey Statistical Institute Address Based Population Registration System data evaluation was carried out the proportion of residents in provincial and district centers in 2015 rose to 92.1%, the proportion 7.9% of people living in towns and villages¹. At the same time, the migration from the village to the city still continues so it is estimated that the urban population will increase further in the future.

Supposing that the human metabolic activities, CO_2 is the first of the fastest changing gases. The composition of air containing 21% O_2 and 0.033% CO_2 taken from the normal atmosphere is converted to 16-17% O2 and 4% CO_2 when exiting the lungs². This change leads to a rapid rise in the amount of CO_2 in public places such as schools, shopping centers and hospitals. At the same time the increase of carbon dioxide ratio in the environment occur some disorders like fatigue, difficulty in detection, drowsiness³. Also the CO_2 leads to various complaints that cause loss of performance in human body. When the amount of CO_2 exceeds 1000 ppm, headache, dizziness, fatigue, concentration disturbances, odor disorders, when over 1500 ppm in the throat and nose irritation, runny nose, cough and eye currents occur in the people⁴.

According to the Energy and Air Pollution report shared by the International Energy Agency (IEA), around 6.5 million people die due to air pollution causes in every year⁵. Only in 2016, 29 thousand people are reported due to air pollution that lost their lives in Turkey⁶. Especially air pollution poses a greater risk for children, elderly, pregnant and sick people in the risk group for health⁷. Therefore, it is more important to determine the air quality in the areas where the people in the risk group are present, as well as the air quality in the cities⁸. The aim of this study was to determine IAQ in some hospitals in Kastamonu in terms of particulate matter and CO_2 level.

MATERIALS AND METHODS

The study was held in four different hospitals located in Kastamonu where a city in Black Sea Region in Turkey is. These hospitals are located very close to the city center (**Figure 1**). During the study, 5 times repetitive measurements were made at 9 different points with dissimilar characteristics in the designated hospitals which are Emergency Entrance, Department of Immediate Leave, Tomography, X-ray, Outpatient Corridor (3 different points) and Hospital Exit, respectively.

Hospital No. 1 (H1.): It was established in1939 with 50 beds as a public hospital. Additions to structure were made in 1965, 1975, 1980, 1986, and 2006 to the main campus established in 1939. The buildings on the Main Campus formed in 5 blocks are connected by corridors. It is the most intensive hospital of Kastamonu.

Hospital No. 2 (H2): The hospital, which was built in 1975 under the Social Security Institution, has a closed area of 6222 m2. It has been operating as the Obstetrics and Gynecology Hospital.

Hospital No. 3 (H3.): It serves as Physical Therapy and Rehabilitation Center. The building, which served as a hospital for many years and after it was used as a Mental Health Hospital, Prison, State Hospital and

Chest Diseases Hospital at different times. The building, which was built in 1969 instead of the old building, was completed in 1976 and was converted into a Rehabilitation Center in 1980.

Hospital 4 (H4.): It is a non-governmental hospital. It is operated by private enterprise. It is a hospital with a capacity of 47 beds.



Figure 1: Locations of the hospitals

The particulate matter measurements of the study were performed with a device that aspirated air for every 15 seconds and gave a particle number of 6 different sizes, while CO_2 measurements were made with IAQ measurement device. These methods are frequently used in air quality studies. The measurements were repeated in summer and in winter.

RESULTS AND DISCUSION

According to the results of the study, pollutant values reach to the highest level in winter months. The values, which have the highest level in H4. According to the measured values, CO_2 levels ranged from 842 ppm to 1065 ppm on a hospital basis (**Figure 2**).





In terms of average value of CO_2 , the lowest was measured in summer and the highest was in winter for H2. This situation means that the most affected by the air change due to fuel use is in H2. The amount of particulate matter is great importance in the measurements especially small size (1 and smaller) particulate matter is more risky for health because it can be transmitted more easily into respiratory channels. These values are higher than the amount of particulate matter which amounts are determined at max level. In summer measurements, only PM 1 was found to be higher (**Table 1**).

HOSPITALS	POLLUTANT	CO ₂		PARTICULATE MATTERS (ppm)											
				0,3		0,5		1		2,5		5		10	
	Season	w	s	w	s	w	s	w	s	w	s	w	S	w	s
H1.	Avg.	924	873	87885	27025	23840	7167	2595	<u>1291</u>	353	169	56	38	32	25
	Max.	1358	1602	196887	71833	57604	19156	5821	11624	700	338	109	84	69	54
	Min.	525	560	38161	11350	1941	2864	988	411	125	73	16	13	4	8
Н2.	Avg.	<u>1065</u>	842	97551	30766	30116	8001	3451	972	496	171	<u>105</u>	36	<u>53</u>	23
	Max.	1463	1058	199789	93199	62467	21660	6403	2571	1229	420	270	73	163	53
	Min.	747	530	21112	13380	5526	2886	668	270	132	51	37	7	22	4
Н3.	Avg.	942	<u>935</u>	127700	28989	38472	7551	4072	943	550	173	86	37	44	23
	Max.	1247	1623	194320	50894	64880	12411	7635	1652	1407	310	460	88	326	58
	Min.	610	597	68300	12867	19077	3333	494	341	258	82	39	15	14	9
H4.	Avg.	974	910	<u>179871</u>	<u>32614</u>	<u>55738</u>	<u>8741</u>	<u>5916</u>	1130	<u>734</u>	<u>216</u>	100	<u>46</u>	46	<u>31</u>
	Max.	1214	1276	254112	54783	84917	14515	9170	1892	1265	390	247	84	115	51
	Min.	694	529	113256	12307	31744	3406	3308	412	357	84	49	13	20	9

Table 1: The Amounts of CO2 and Particulate Matter (PM) in the Hospitals

CONCLUSION

The results obtained from the study show that hospitals do not exceed the limit values for the pollutants studied. For example, CO_2 was measured as an average of 1065 ppm. The EPA indicates that the amount of CO2 should not exceed 1200 ppm indoors⁹. However, it has been determined that the amount of CO₂ is exceed this value and also it reaches to 4000 ppm levels in the schools¹⁰.

It is noteworthy that the lowest and highest CO_2 , 5 µm and 10 µm particle sizes were measured in H2. This result shows the importance of hospital location in urban planning process. Because, the most effective way to improve IAQ need to ventilate the indoor. Studies show that the ambient air is much cleaner than the interior. However, by ventilating the environment, IAQ can increased by the active pollutant removal or ventilation. Therefore, the air quality of the region where is the hospital should be established in terms of the clean air. The study states that the air pollution in the city center varies regionally in terms of CO_2 and PM, which is affected by many conditions¹¹. Due to the importance of air quality in urban centers, many studies have been carried out on this subject. Similar studies are also involved in Cracow, in Rome, in Korea, in Hawaii; also air pollution level has been identified in various cities in Turkey's ¹²⁻¹⁶.

Also in this study, the change of PM amount was determined which is defined as a suspension of fine solids or liquids in a gas, resulting from natural sources such as wind, sea and volcanoes, or from anthropogenic activities, and is generally included in the literature as aerosols. It has been determined that the amount of particulate matter reaches the results that will negatively affect to human health in areas where traffic is very intense¹⁷. The PM was conducted such as in Aydın, Büyükçekmece Basin, İzmir and Malatya in the other studies¹⁸⁻²².

The hospitals are located Cumhuriyet Square and Old Industries where the pollution values are highest according to the measurement results in Kastamonu²³. For this reason, the concentration of air pollution, the prevailing wind direction and so on while conducting site selection analysis of the health facility and some criteria must be taken into account. Another issue to be considered that is the state of the environment of the hospital gardens. Especially in areas away from construction and traffic density, areas surrounded by forest areas should be preferred as much as possible. The studies show that the air of the forest areas is clearer in both summer and winter than in urban centers. The landscape quality of hospital gardens should be taken into account when considering the air quality. Because the plants reduce all kinds of air pollution, as well as soil protection, wildlife support, water regime, such as the fulfillment of many functions. However, in addition to these functions, plants have a significant impact on human psychology, which is already known to influence the healing process of patient psychology. Therefore, planting activities of hospitals are of great importance.

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