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Research Article

Comprehensive Environmental Monitoring based on Stations of Environmental Pollutants (Air, Water and Soil) in Tehran

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Abstract
This research is conducted with an aim of locating the monitoring stations of environmental pollutants (air, water and soil) and monitoring management of such pollutants in Tehran. Given the nature of the research and the factors and elements investigated in this study, the research method is in the line of descriptive-analytical studies, and in terms of objective, this is an applied-developmental research. In summary, the specific and practical purposes of this research include; determining the factors, criteria and sub-criteria associated with monitoring of environmental pollutants (air, water and soil), prioritizing and ranking the criteria and sub-criteria of indicators with a specific logic, and providing a pattern for management on monitoring of environmental pollutants in Tehran. ArcGis software was applied for data analysis and providing digital and basic maps. Analytic network process (ANP) was used for weighting the indicators studied in the research and the fuzzy logic model was used for data analysis and overlapping. According to the table of verbal and numerical scales based on hourly method, a pairwise comparison was performed between air, water and soil environments based on importance and preference and the data were imported into the Super-Decision software. According to the output of this software, the air weight of 673, water weight of 226, and soil weight of 101 were obtained, respectively. As a result, this output showed us that air is ranked first, water is ranked second, and soil is ranked third, in terms of importance. From the results and prepared (weighted) maps and also in response to the research hypotheses, it was found that some of the available stations are not properly located. Finally, the location of monitoring stations was presented in four classes of very desirable, desirable, relatively desirable, and undesirable.

Keywords: Monitoring stations, location, monitoring indicators, ANP model, Super Decision software

Introduction

Tehran, like many other metropolitan areas worldwide, is dealing with numerous environmental problems, such as air, water and soil pollution. For identifying the indicators of these pollutants,

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the control, decline, and management decision-making on continuous monitoring of these pollutants are required. In other words, the goal is to achieve an efficient management by identifying the sources of environmental pollutants and providing a strategic model with a sustainable urban development approach and using proper opportunities for favorable and sustainable productivity by determining indicators, criteria, and sub-criteria related to monitoring of environmental pollutants and ranking and prioritizing these indicators with a certain logic by ANP model, upon which the implementation and layout of monitoring stations will be conducted in GIS environment.

Although the software was not very common until the mid-1990s even in the advanced countries of the world, but since 1999, the use of these systems has been increasing in spatial-spatial analysis of water, air and soil pollution (Safavi and Alijani, 2006).

In recent years, numerous studies are conducted by experts and researchers worldwide on examining and identifying environmental pollutants and their monitoring and management using various statistical systems, models and software, which can be mentioned in the following; in 2010, in a study entitled "Understanding the transportation pollution problem versus environmental air quality", the transportation was noted as the major cause of urban pollution, believing that 30-80% of total air pollution is caused by vehicles. In this research, an association between population and air pollution and type of atmospheric pollutants (CO_2, NO_2, SO_2 and NO_X) caused by the use of fossil fuels, especially lead-containing gasoline, was made in the crowded areas. Also, at the end of the research, the air pollution index was determined per PSI in these locations (De Nevers, 2010). In 2008, in a study called "Tehran's air quality assessment using air quality index", the air pollutant monitoring stations were analyzed. In this year, Tehran's air quality exceeded the EPA-defined standard and 84% carbon monoxide pollutant was also reported (Biglari et al., 2017).

In 2002, in a paper entitled "Air polluted sites and the effects of traffic air pollution on human health in Denmark", the distribution of air polluted sites and the effects of air pollutants such as SO_2, NO_2, NO_X. CO, O_3, PM_{10} on the health of individuals were investigated. The results showed that the most polluted sites by the atmospheric pollutants are in the crowded and busy urban areas. The models used for this research are the advanced models such as urban history regional grading model and street pollution model (Skjøth. et al. 2007).

In a research entitled "Most important sources of sulfur dioxide and carbon monoxide accumulation at Stockholm", at first, the spatial-temporal correlation analysis of sites polluted by sulfur dioxide and temperature inversion were investigated, and then it was explained that the most distributed type of pollutants associated with the vertical temperature gradient at 37 m above surface in the early morning hours is a good indicator for air pollution prediction (Rückerl et al., 2007).

Goovaerts et al. (2004), used specific vector methods to study spatial distribution patterns and types of air pollutants and to determine air pollution indicators using a graphical model in Michigan. Specific vector coefficients as dependent variables had been a function of meteorological parameters in stepwise multiple regression analysis. The data were first normalized and the vector and specific vector coefficient were calculated, and the primary specific vectors of diffraction showed the early observations of sulfur oxide. The variables used in the regression equations are: air temperature, measurable precipitation, mixing height, stability, mean wind vector components, and arithmetic mean wind speed at ground level (Goovaerts et al., 2004).

In general, the air pollution in Iranian metropolitan areas is directly related to the type and amount of pollutants with densely populated blocks in crowded and populated urban areas in terms of geographical and temporal context (Hoek et al., 2008). In other words, it can be said that each pollution phenomenon has its own spatial and temporal coordinates in terms of concentration and type of pollutant (Wang et al., 2018). One of the most challenging processes in creating and increasing the air pollution is irregular settlement and urbanization in the suburbs of metropolitan areas. The process of urbanization in developing countries, such as Iran, with the increased number and size of cities and their rapidly growing population leads to issues such as informal economy and housing and high population density in the main old places of the city, which will be followed by an increase in air pollution and various pollutants in the atmosphere on the cities (Amirahmad and Ali, 2017). Geographic Information System (GIS) along with Multi-Criteria Decision Making (MCDM) can effectively be used in monitoring and management of atmospheric pollution data to investigate the spatial distribution of different pollutants and the trend of changes in pollution rate as the Environmental Decision Support System (EDSS) in intelligent control and management of air pollution crisis in metropolitan areas (Ceccaroni, 2004).

Air pollution data are considered a key element for studies and making decisions on its decline and control, which is prepared by pollutant monitoring stations (Mohammadi-Zadeh et al., 2016; Eghbal et al., 2019). Hence, establishing new stations and their exact layout are significantly important. So that with proper layout of pollution monitoring stations, a better actual situation of pollution is achieved, therefore, one of the most important considerations in the implementation of the air pollution control system is choosing suitable locations for stations (Mohammadi-Zadeh et al., 2017; Shirani-Bidabadi et al., 2019).

Methods and Materials

Research method

At the beginning of this research, the efforts were made to investigate the articles, books and journals, internet search, and literature review of research from internal and external sources and later on the collection of quantitative and qualitative statistics on environmental pollutants and review of current situation in Tehran. Then, the content of this information that composes a part of the checklists related to the environmental pollutants from internal and external sources were used to prepare an expert questionnaire. After designing and preparing the questionnaires under the supervision of assistant professors, the questionnaires were distributed among 10 experts and were completed. Then, based on the experts' opinions, the origin, factor, criteria and indicators of environmental pollutants (air, water and soil) were extracted and identified.

In the next step, using the Super-Decision software and ANP method for each of the pollutants, the origin, factors, criteria and indicators were weighed, and then the indicators and sub-indicators were ranked for each pollutant at the studied regional scale, which is the city of Tehran (Padash et al., 2020; Padash and Ataee, 2019; Danesh et al., 2019).

The main importance of the ANP method is that this method can be used to solve unstructured problems. In fact, in this method, different clusters must be identified and the interface between them must be determined (Wu et al., 2020; Fei, 2020; Abbaspour et al., 2020). There is no need for hierarchical order of purpose, criteria and sub-criteria.

This technique includes the following steps:

- Determine the corners and determine the relationships between them.
- Determine the weight of the clusters by comparing the pairs and based on their relationships.
- Determine the weight of the internal elements of the clusters based on the pairwise comparison and their internal relationships.
- Put the results together in the form of a super matrix to form the primary super matrix (imbalance).

- Manually convert the initial super matrix to a harmonized super matrix.
- Calculate the maximum limit.

Once the weight of the main criteria has been determined based on the purpose and their internal relationships, and the weight of the sub-criteria has been determined in their cluster, the special vector of all these matrices is put together and a super matrix or super matrix is formed. This primary super matrix should be normalized (Khan et al., 2020; Dinan et al., 2020; Alizadeh et al., 2020; Tian and Peng, 2020). For normalization, it is normalized from the linear method and converted into a harmonic super matrix. A balanced super matrix must reach a large power, usually between 8 and 13, so that all the valves in each row are equal or convergent. The values of each line are the weight of the element in that line. You must use supersonic software to determine the limit symmetry.

The Super-Decision software provides three outputs; ideal weight, low weight, and normal weight. In this research, the ideal weight is considered as the criteria, then using the ARC-GIS software, the implementation and layout of monitoring stations in the GIS environment was accomplished based on the resulting weights (Zhou et al., 2020; Gaafar et al., 2020; Dwivedi et al., 2020; Padash, 2017; Nasab et al., 2017). At the end of the research, after determining the location of monitoring stations at four levels of very desirable, desirable, relatively desirable, and undesirable, and a comparison with current situation, a pattern of pollutant monitoring management was presented for city of Tehran.

Data analysis tools

The following tools and materials were used to conduct the research as best as possible. Here's how to use each in the output analysis.

- Questionnaires for data collection on factors affecting the pollutant monitoring management, including origin, factor, criterion and indicators.
- Table of verbal and numerical scales based on the hourly method for pairwise comparison of the components.
- Super-Decision software for implementing ANP technique (Modak et al., 2019; Wu et al., 2019; Chen et al., 2019).
- Preparing digital subject maps of research area.
- ARC-GIS software for providing a layout and map of monitoring stations (Zhang et al., 2020; Bachagha et al., 2020; Chen et al., 2020).

Basic and identification studies, preparation of checklists, results of expert opinion survey, and extraction of questionnaire results

In this section, the results of expert opinion survey are presented. The preparation and content of the questionnaires were conducted by obtaining the opinions of assistant professors, and factors affecting the management monitoring of urban environmental pollutants and factors related to the location of subject monitoring stations (air, water and soil) were determined by origin, factor, criteria and sub-criteria (indicators), and then, the completed questionnaires were extracted.

Providing pairwise comparison tables for each pollutant

Pairwise comparison tables for air, water and soil environments were evaluated based on the table of their corresponding verbal and numerical scales with respect to importance or priority of comparison based on hourly method (Kazemi-Beydokhti et al., 2019; AlAttar et al., 2019). In fact, we are looking for effective factors in determining and locating monitoring stations.

Calculating the arithmetic mean of the pairwise comparison for air, water and soil

In this section, the arithmetic mean of pairwise comparison for air, water, and soil were calculated for all origins, factors, criteria, and indicators, respectively, which is summarized below. In the next step, a pairwise comparative matrix is prepared from the arithmetic mean, which will be used for data entry into the Super-Decision software and weighting and ranking of the pollutants (Asif and Chen, 2019; Moslem et al., 2019).

Providing a pairwise comparison matrix for origins, factors, criteria, and indicators, for air, water and soil environments, respectively

In this section, a pairwise comparison matrix was prepared for all origins, factors, criteria and indicators for the air, water and soil environments, respectively. For example, in the pairwise comparison of (a1) with (a2), because (a2) or weight to the right side of table is heavier, as a result, the mean that was 6 is displayed as 1.6, and in the comparison of (a2) with (a1), the inversed 1.6 that is 6 is displayed. Also, in the pairwise comparison of the same factors such as (a1) with (a1) or (a2) with (a2) and so on, 1 is considered. This will be the same for all pairwise comparisons. Then, the data were entered Super-Decision software, and the pollutants are weighted and ranked via ANP model. An example of one of the pairwise comparison matrices for air (origin and factor) can be seen in Table 1.

Table 1. Pairwise comparison matrices for air (origin and factor)

Pairwise comparison matrices for air (origin) (A)		
a2	a1	Origin
1.6	1	a1
1	6	a2
a1=Natural; a2=Unnatural		

Pairwise comparison matrices for air (factor) (A)		
a12	a11	Factor
4	1	a11
1	1.4	a12
a11=Air and climate properties; a2=Geomorphological properties		

Results and Discussion

Results of extracting and summarizing the origin, factor, criteria and sub-criteria (indicators) for each of the environments (air, water and soil)

Factors affecting monitoring management of urban environmental pollutants for locating air monitoring stations are described in Table 2. The origin consists of two parts:

A. Natural origin, B. Unnatural origin. The details of each of the factors, criteria and indicators with resulting weights and their ranking presented in Table 2-A and Table 2-B. In Table 2-A, the weight of Origin is 143 and the ranking is 2.

B. Unnatural origin (man-made): Details of unnatural origin including factors, criteria, and indicators along with their weights and ranking are presented in continued Table 2-B. In Table 2 B, the weight of origin is 857 and the rank is 1.

Table 2-A. Determining the weight of factor, criteria, and sub-criteria for locating the air pollution monitoring

Factor			**Criteria**			**Sub-criteria (indicator)**		
Description	Weight	Ranking	Description	Weight	Ranking	Description	Weight	Ranking
Air and climate properties (a11)	114.4	1	Average annual precipitation (a111)	50.3	1	Monthly distribution (a1111)	42	1
						Seasonal distribution (a1112)	8.4	2
			Average annual air temperature (a 112)	8.7	4	Monthly distribution (a1121)	2.2	2
						Seasonal distribution (a1122)	6.5	1
			Average annual relative humidity (a113)	16.4	3	Monthly distribution (a1131)	13.1	1
						Seasonal distribution (a1132)	3.3	2
			Maximum and minimum wind intensity and wind direction (a114)	39.0	2	Monthly distribution (a1141)	33.4	1
						Seasonal distribution (a1142)	5.6	2
Geomorphological properties (a12)	28.6	2	Mountain (a121)	19.3	1	High (a1211)	4.8	2
						Relatively high (a1212)	14.5	1
			Hill (a122)	6.4	2	High (a1221)	5.1	1
						Relatively high (a1222)	1.3	2
			Plain (a123)	2.9	3	Outdoor plain (a1231)	0.7	2
						Indoor plain (a1232)	2.2	1

According to the descriptions mentioned on the air, a total of 2 origins, 4 factors, 13 criteria and 38 sub-criteria (indicators) were evaluated in the expert survey, and consequently, the cases with less than 5 votes were eliminated, and those with 5 or above statistics with the condition of 50% of the votes were evaluated for the next stage of research, which is the preparation of pairwise comparison tables for air, water and soil environments based on corresponding verbal and numerical scales with respect to importance or preference of hourly method based comparison. Accordingly, two criteria of terrace and playa and its indicators, alluvial and clay pan, which received less than 5 votes were eliminated.

Factors affecting the monitoring management of urban environmental pollutants for locating water monitoring stations were determined as follows:

Origin, consisting of two sections: A. natural origin, B. unnatural origin (man-made)

A. Natural origin: Details of factors, criteria, indicators, along with their weight and ranking are presented in Table 3 A and Table 3 B. In Table 3-A, weight of origin is 125 and the rank is 2.

B. Unnatural origin (man-made): Details of unnatural origin including factors, criteria, and indicators along with their weights and ranking are presented in continued Table 3-B. In Table 3-B, the weight of origin 875 and the rank is 1.

Table 2-B. Determining the weight of factor, criteria, and sub-criteria for locating the air pollution monitoring

Factor			Criteria			Sub-criteria (indicator)		
Description	Weight	Ranking	Description	Weight	Ranking	Description	Weight	Ranking
Land use properties (a21)	171.4	2	Urban (a211)	87.7	1	Residential areas density - Population density (a2111)	11.4	3
						Industrial areas density (a2112)	41.7	1
						Service areas and centers density (a2113)	3.8	5
						Public road density - Vehicle density (alley, street, highway & freeway) (a2114)	18.7	2
						Green space density (public and private) (a2115)	2.4	6
						Urban areas density (a2116)	7.8	4
			Suburban (a212)	82.7	2	Industrial suburban areas density (a2121)	24.1	2
						Industrial outside urban areas density (a2121)	25.9	1
						Residential suburban areas density (a2123)	15.3	3
						Public and private suburban green spaces density (a2124)	2.4	7
						Arid urban outdoor spaces density (a2125)	3.8	6
						Arid suburban outdoor spaces density (a2126)	10.1	4
						Arid outside urban outdoor spaces density (a2127)	4.2	5
Air pollution reduction and control programs and equipment (a22)	685.6	1	Infrastructure facilities, and equipment (a221)	127.1	2	Subway (a2211)	4.3	6
						Bus (a2212)	40.7	2
						Taxi (a2213)	28.9	3
						Gas station (a2214)	11.7	4
						Gas network (a2215)	5.3	5
						Distribution of service centers (schools, health centers, daily shopping centers, etc.) (a2116)	46.2	1
			Pollution reduction and control plans (a222)	548.5	1	Traffic plan (a2221)	64.2	3
						Urban development plans (a2222)	###	1
						Future city development plans (a2223)	147	2
Total T. 2 A,B	**1000**			**1000**			**1000**	

Table 3-A. Determining the weight of factor, criteria, and sub-criteria for locating water pollution monitoring

Factor			**Criteria**			**Sub-criteria (indicator)**		
Description	Weight	Ranking	Description	Weight	Ranking	Description	Weight	Ranking
Air and climate properties (b11)	9.4	4	Average annual precipitation (b111)	6.3	1	Average annual spatial precipitation height (b1111)	1.1	2
						Average annual temporal precipitation height (b1112)	5.3	1
			Average annual air temperature (b112)	1	3	Average annual spatial air temperature (b1121)	0.2	2
						Average annual temporal temperature (b1122)	0.8	1
			Average annual evaporation (b113)	2.1	2	Average annual spatial evaporation (b1131)	0.4	2
						Average annual temporal evaporation (b1132)	1.7	1
Geomorphological properties (b12)	5	6	Mountain (b121)	4	1	Elevated (b1211)	4	1
			Playa (b125)	1	2	Clay pan (b1251)	1	1
Geological properties (b13)	33	3	Surface geology (lithology) (b131)	26	1	Igneous rocks (b1311)	7.1	2
						Sedimentary rocks (b1312)	16	1
						Metamorphic rocks (b1313)	3.1	3
			Subsurface geology (b132)	6.6	2	Alluvial formations (b1321)	4.1	1
						Sedimentary formations (b1322)	1.8	2
						Igneous formations (b1323)	0.7	3
Soil properties (b14)	35.4	1	Physical properties (b141)	5.9	2	Type (b1411)	0.6	3
						Land unit (b1412)	1	2
						Texture (b1413)	4.3	1
			Chemical properties (b142)	30	1	Acidity (pH) (b1421)	2.2	3
						Electrical conductivity (EC) (b1422)	22	1
						Organic matter (OM) (b1423)	4.4	2
Physiographic properties (b15)	8.4	5	Degree of slope (b152)	6.3	1	Less than 5% (b1521)	5	1
						5 -20% (b1522)	1.3	2
			Drainage network density (b153)	2.1	2	Less than 500 m/ha (b1531)	0.1	4
						500-1000 m/ha (b1532)	0.2	3
						1000- 2000 m/ha (b1533)	0.5	2
						More than 2000 m/ha (b1534)	1.3	1
Vegetation (b16)	33.9	2	Forest (b161)	34	1	Type (b1611)	4.8	2
						Density (b1612)	29	1

Table 3-B. Determining the weight of factor, criteria, and sub-criteria for locating the water pollution monitoring

Factor			Criteria			Sub-criteria (indicator)		
Description	Weight	Ranking	Description	Weight	Ranking	Description	Weight	Ranking
Land use Properties (b21)	875	1	Urban (b211)	541	1	Residential areas density - Population density (b2111)	6.6	7
						Industrial areas density (b2112)	22	4
						Service areas and centers density (b2113)	7.6	6
						Public road density - Vehicle density (b2114)	5.4	8
						Drainage network density (b2115)	14	5
						Green space density (b2116)	3.5	9
						Sewer network density (b2117)	46	2
						Municipal waste (b2118)	41	3
			Suburban (212b)	335	2	Suburban wells	394	1
						industrial areas density in watersheds near the city (b2122)	160	1
						Residential suburban areas density (rural density) (b2123)	107	2
						Garden density and water farming in watersheds near the city (b2124)	39	3
						Dryland farming density in watersheds near the city (b2125)	28	4
Total T. 3A,B	**1000**			**1000**			**1000**	

According to the descriptions mentioned on the water, a total of 2 origins, 8 factors, 20 criteria and 53 sub-criteria (indicators) were evaluated in the expert survey, and consequently, the cases with less than 5 votes were eliminated, and those with 5 or above statistics with the condition of 50% of the votes were evaluated for the next stage of research, which is the preparation of pairwise comparison tables for air, water and soil environments based on corresponding verbal and numerical scales with respect to importance or preference of hourly method based comparison. Accordingly, 5 sub-criteria or indicators of geomorphological properties that received less than 5 votes and 4 sub-criteria (indicators) of physiographic properties as well as 4 sub-criteria of vegetation related to the natural origin were eliminated. Factors affecting the monitoring management of urban environmental pollutants for locating water monitoring stations were determined as follows:

Origin, consisting of two sections: a. natural origin, b. unnatural origin (man-made)

A. Natural origin: Details of factors, criteria, indicators, along with their weight and ranking are presented in Table 4-A and Table 4-B. In Table 4-A, the weight of origin is 166 and the rank is 2.

B. Unnatural origin (man-made): Details of unnatural origin including factors, criteria, and indicators along with their weights and ranking are presented in continued Table 4-B. In table 4-B, the weight of origin is 834 and the rank is 1.

Table 4-A. Determining the weight of factor, criteria, and sub-criteria for locating water pollution monitoring

Factor			Criteria			Sub-criteria (indicator)		
Description	Weight	Ranking	Description	Weight	Ranking	Description	Weight	Ranking
Air and climate properties (c11)	12.8	4	Average annual precipitation (c111)	8.9	1	Average annual spatial precipitation height (c1111)	8.9	1
			Average annual air temperature (c112)	1	3	Average annual spatial air temperature (c1121)	1.0	3
			Average annual evaporation (c113)	2.9	2	Average annual spatial evaporation (c1131)	2.9	2
Geological properties (c12)	23.9	3	Geological formation type (c121)	1.6	3	Igneous and metamorphic formations (c1211)	1.3	1
						Sedimentary formations (alluvial and loess) (c1212)	0.3	2
			Mineralogical properties of formations (c122)	7	2	Igneous and metamorphic formations (c1221)	1.0	2
						Sedimentary formations (alluvial and loess) (c1222)	6.0	1
			Weathering status (c123)	15	1	High (c1231)	9.8	1
						Medium (c1232)	4.5	2
						Low (c1233)	1.0	3
Landform properties (c13)	10.0	5	Land type (c131)	9	1	Mountain (c1311)	4.9	1
						Hill (c1312)	3.1	2
						Plateau (c1313)	0.9	3
						Plain (c1314)	0.1	4
Soil properties (c14)	51.3	2	Type (c141)	38	1	Evolved (c1411)	37.6	1
			Tissue (c142)	3.5	3	Clay (c1421)	2.4	1
						Sand (c1422)	0.3	3
						Silica (c1423)	0.8	2
			Depth (c143)	10	2	Shallow (c1431)	1.0	3
						Semi-deep (c1432)	2.3	2
						Deep (c1433)	6.9	1
Topographic and physiographic properties (c 115)	7.0	6	Land slope (c152)	7	1	Less than 5% (c1521)	0.5	3
						5- 20% (c1522)	1.4	2
						More than 20% (c1523)	5.1	1
Hydrological properties (c16)	61.1	1	Drainage density (c161)	38	1	Less than 500 m/ha (c1611)	1.7	4
						500-1000 m/ha (c1612)	3.1	3
						1000-2000 m/ha (c1613)	9.7	2
						More than 2000 m/ha (c1614)	23.7	1
			Surface water quality (c162)	17	2	Containing sewage and wastewater (c1621)	1.2	3
						Containing medium amount of sewage and wastewater (c1622)	3.4	2
						Containing large amount of sewage and wastewater (c1623)	12.5	1
			Groundwater properties (c163)	5.3	3	Low pollution (c1631)	0.4	3
						Moderate pollution (c1632)	1.0	2
						High pollution (c1633)	4.1	1

Table 4-B. Determining the weight of factor, criteria, and sub-criteria for locating the soil pollution monitoring

Factor			Criteria			Sub-criteria (indicator)		
Description	Weight	Ranking	Description	Weight	Ranking	Description	Weight	Ranking
Land use properties (c21)	834.0	1	Urban (c211)	696	1	Residential (c2111)	28.5	6
						Commercial-residential (c2112)	62.0	5
						Commercial (c2113)	81.4	4
						Commercial Industrial (c2114)	208.0	1
						Industrial (c2115)	178.8	2
						Combined (c2116)	135.6	3
			Suburbs (c212)	138	2	Dry farming (c2121)	13.4	3
						Water farming (c2121)	46.1	2
						Residential (suburbs) (c2123)	78.9	1
Total T. 4A,B	**1000**			**1000**			**1000**	

According to the descriptions mentioned on the air, a total of 2 origins, 8 factors, 21 criteria and 62 sub-criteria (indicators) were evaluated in the expert survey, and consequently, the cases with less than 5 votes were eliminated, and those with 5 or above statistics with the condition of 50% of the votes were evaluated for the next stage of research, which is the preparation of pairwise comparison tables for air, water and soil environments based on corresponding verbal and numerical scales with respect to importance or preference of hourly method based comparison. Accordingly, 1 factor of natural protection properties on the ground along with its criteria and indicators and 2 indicators derived from suburban criteria of unnatural origin (man-made) that received less than 5 votes were eliminated.

Providing a pairwise comparison matrix for air, water and soil

As can be seen in Table 5, based on numerical and verbal scales based on hourly method, a pairwise comparison for air, water and soil environments was performed as shown in the following table and based on importance and preference, and data were imported into Super-Decision software, and based on the output of this software, the air weight of 673, water weight of 226, and soil weight of 101 were obtained, respectively. As a result, this output showed us that air is ranked first, water is ranked second, and soil is ranked third, in terms of importance.

Table 5. Comparison matrix for air (A) water (B) soil (C)

	A	B	C
A	1	5	6
B	1.5	1	7
C	1.6	1.7	1

Providing location maps for air, water and soil monitoring stations

As seen in figure 1, four classes were extracted for locating the air monitoring station, including class 1 with 125 spots (Blue color) as the first class station (with the highest weight between 0.0322-0.0612), class 2 with 225 spots (Red color) as the second class station (with weight between 0.0171-0.0321), class 3 with 263 spots (Green color) as the third class station (with weight between 0.0063-0.017), and class 4 with 84 spots (Yellow color) as the fourth class station (with weight between 0-0.0062), which were determined for air monitoring station.

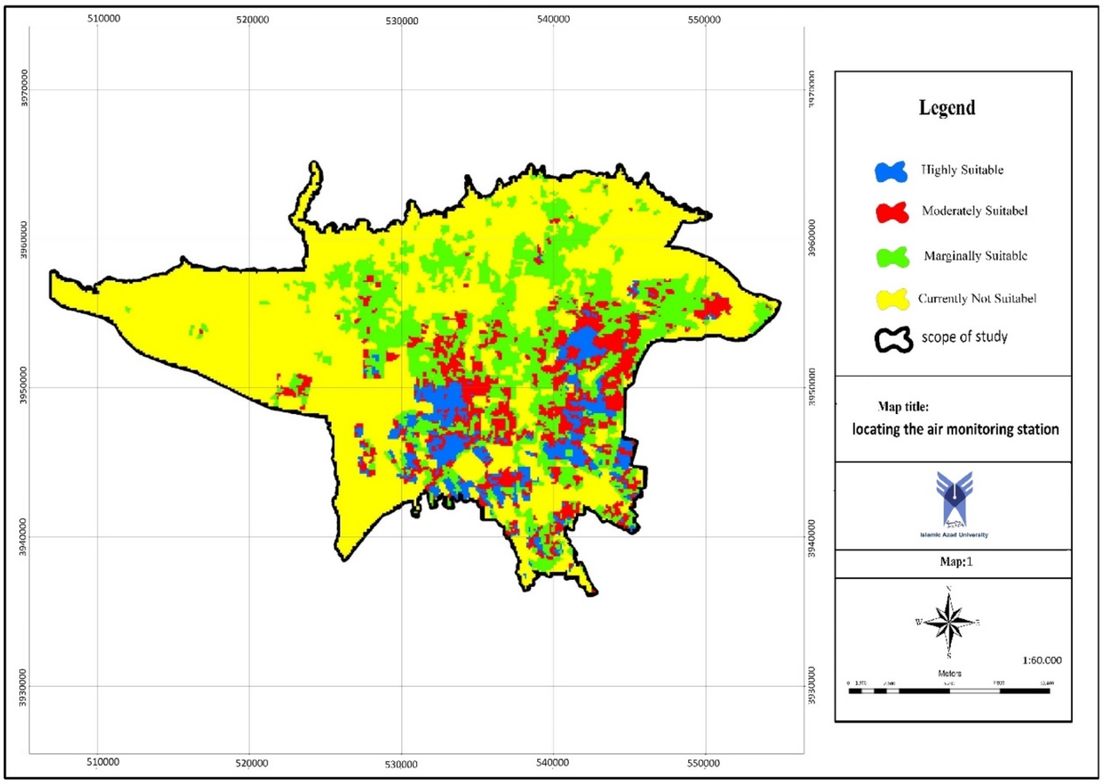

Figure 1. Location map of the air monitoring station

As seen in figure 2, four classes were extracted for locating the water monitoring station, including class 1 with 46 spots (Blue color) as the first class station (with the highest weight between 0.0074-0.02), class 2 with 61 spots (Red color) as the second class station (with weight between 0.0025-0.0073), class 3 with 152 spots (Green color) as the third class station (with weight between 0.0004-0.0024), and class 4 with 89 spots (Yellow color) as the fourth class station (with weight between 0-0.0003), which were determined for surface and subsurface water monitoring station.

As seen in figure 3, four classes were extracted for locating the soil monitoring station, including class 1 with 152 spots (Blue color) as the first class station (with the highest weight between 0.0179-0.0325), class 2 with 220 spots (Red color) as the second class station (with weight between 0.0132-0.0178), class 3 with 213 spots (Green color) as the third class station (with weight between 0.0082-0.0131), and class 4 with 92 spots (yellow) as the fourth class station (with weight between 0-0.0003), which were determined for soil monitoring station.

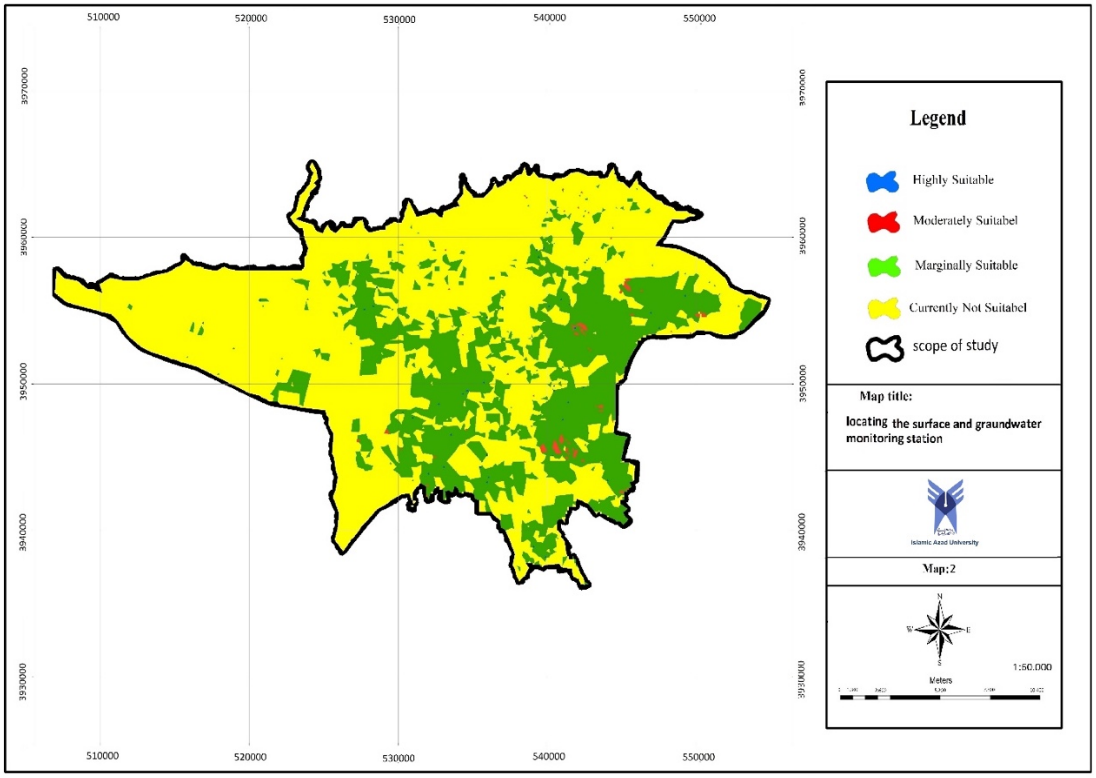

Figure 2. Location map of surface and subsurface water monitoring station

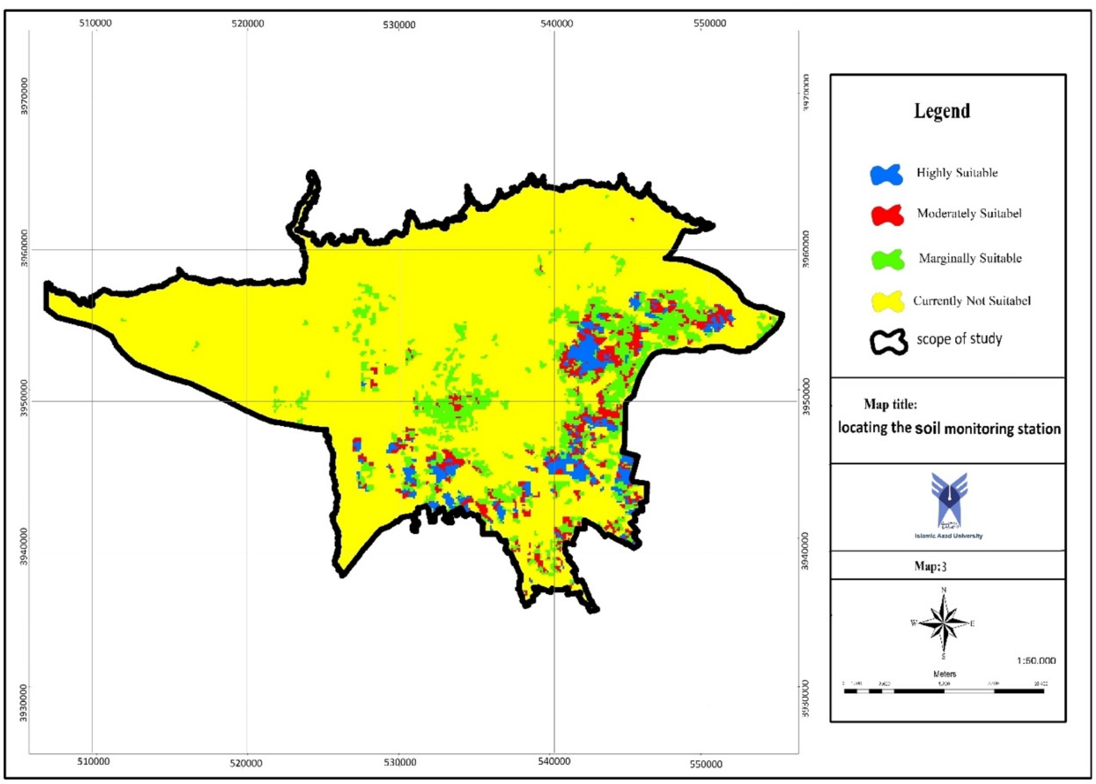

Figure 3. Location map of soil monitoring station

Conclusion:

For this research, descriptive data were first collected by extracting the experts' opinions from the questionnaires, and then digitization was done for the air, soil and water layers. Then, based on the origin, factors, criteria and sub-criteria (indicators) and considering effective factors via ANP model and fuzzy logic using Super Decision software, the criteria, sub-criteria and indicators were weighted and ranked. Software gives us a weight for all the criteria or sub-criteria, and the sum of weights becomes 1, in other words, the weight range is from 0 to 1. The closer weight of criteria and sub-criteria to 1, it is acceptable and desirable, and the closer weight to 0, it is unacceptable and undesirable. Since the weights of the resulting indicators are very small (from a few hundredths to a few ten thousandths or smaller), all weights were multiplied by 1000 to simplify their ranking. Layers used in this analysis are: 1. Air layers: including 11 criteria and 36 sub-criteria (indicators), 2. Soil layers: including 16 criteria and 43 sub-criteria (indicators), 3. Water layers: including 14 criteria and 40 sub-criteria (indicators).

According to overlapping of the maps, the data analysis was carried out in ArcGIS environment, and the final maps of the location of subject monitoring stations for air, soil, and water were specified in four classes of monitoring stations, including 1. First class stations that all parameters and indicators of air, soil and water pollutants for these stations should be measured and monitored with respect to critical conditions in terms of content and concentration of pollutants. 2. Second class stations that have more an appropriate situation in terms of the content and concentration of pollutants compared to the first class stations, and depending on the environmental conditions of the region, the number of parameters and indicators of air, soil and water pollutants for measurement and monitoring are more limited than the first class stations. 3. Third class stations that are intermediate similar to the second class stations, but with fewer parameters for measurement and monitoring. 4. Fourth class stations with relatively clean environmental conditions of the area in terms of the content and concentration of pollutants, and it merely requires to measure and monitor the parameters of the main indicators, for example, only the indicators (CO, SO_2, NO_X, PM_{10}, $PM_{2.5}$, CO_2, SO_X) are measured and monitored in the located fourth class air stations.

Finally, according to the table of verbal and numerical scales based on hourly method, a pairwise comparison was performed between air, water and soil environments based on importance and preference and the data were imported into the Super-Decision software, and based on the results of this software, the air weight of 673, water weight of 226, and soil weight of 101 were calculated. The research findings show that air pollutant is ranked first, water pollutant is ranked second, and soil pollutant is ranked third in terms of importance and control.

Suggestions

It is suggested to parcel all the districts of Tehran for monitoring stations of air, soil, and surface and subsurface water:

- Dimensions and area of each parcel should be specified
- Stations can be seen inside each parcel (air, soil, water)
- Surface and groundwater stations should be separated

Surface water stations should be selected in a way that the high station is considered as a control for the low station, so that the performance of each district of Tehran is measured in output of downstream surface water (channels) of the region. This means, for example, selecting a station in upstream and downstream of reach region. For instance, the low station of district 15 is a control for district 20, and the low station of district 14 is a control for district 15, and so on. Consequently, it can be stated that the results are correct and very close to reality. Once the control station of the upstream district contains pollutants compared to the standard, the pollution is transferred to downstream, which means that the upstream district has problems in environmental management of surface water resources, thus, the efforts must be done for identifying the polluted sites and managing, controlling, and reducing the water pollutants. Since the number of stations is not sufficient for regular and accurate monitoring of pollutants (air, water and soil), in order to complete and optimize the database for monitoring stations of pollutants, it is suggested to establish the pollutant monitoring networks, provide a comprehensive database of pollutants, and develop the national standards for permitted levels of pollutants considering the climatic and topographical conditions of Tehran, and also, to establish the subject pollutant measurement and monitoring stations in clean areas to compare them with stations in areas having additional pressures and impacts on increased environmental pollution in Tehran, due to the independent variables, such as relatively large floating population, political sites, and cultural centers.

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