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MONITORING OF AIR POLLUTION USING EARTH OBSERVATION GROUND STATIONS AND GIS IN TRNC

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Key words: Air Pollution; GIS; Remote Sensing; Pollutant, Ground station.

This paper presents monitoring of air pollution using earth observation ground station and GIS in Turkish Republic of Northern Cyprus, TRNC is becoming highly polluted, due to the high emission of pollutant like; particulate matter, sulfuric oxide, nitrogen dioxide and ozone. This could be possibly as a result of high industrial activity in the region. The need to measure the level of air pollutant brought about this paper in some selected cities. The ground observation stations collect daily amounts of pollutants in the selected cities for the period of 24 months (2011-2012). The data were analyst using excel software. The results shows that during the winter season Alevkayasi has the minimum value of PM_{10} as 4.1 µg/m^3 in January while the maximum was obtained at Famagusta as 180.3 µg/m^3 , during the same winter season in February, the minimum AOD was obtained at Famagusta as 0.3 DU in February and the maximum at Nicosia and Alevkayasi all in February as 1.9 DU. During spring season the minimum value of PM_{10} was obtained at Alevkayasi as 6.9 µg/m^3 in March and the maximum value at Guzelyurt as 286.4 µg/m^3 in March while for the AOD, the minimum was obtained at Klecik as 0.1 DU in may and the maximum at Kyrenia in march. During summer season the minimum value of PM_{10} was obtained at Alevkaysi as 8.8 µg/m^3 in June and the maximum at Guzelyurt as 110.9 µg/m^3 in June, for the AOD the minimum was 0.1 DU at Kalecik in June while the maximum was obtained at Alevkayasi and Nicosia as 1.9 DU in June lastly for Autumn season, the minimum value of PM_{10} was obtained at Alevkayasi in November as 4.6 µg/m^3 and the maximum as 382.4 µg/m^3 at Kyrenia in October, for the AOD the minimum was obtained as 0.3 DU in October while the maximum was obtained as 0.14 DU in October at Nicosia respectively.

1. Introduction

Air pollution refers to the distortion of the quality of air which brings along with it diverse effect on humans and the environment; It is a genuine natural issue that has created great consequences, encompassing; ascends in respiratory illnesses and exacerbated wellbeing conditions for the aged, together with activities delayed because of poor perceptibility in developing nations, in this case, air pollution in the major Chinese cities communities has crumbled quickly in the course of the most recent three decades amid which the national economy began to grow [1]. More so, rapid industrialization, advancement of private vehicles, and fast growing development area has added to an exponential increment in suspended particulates in the air. [34]; reveals that, polluted air has disturbed social agreement and upset financial advancement in China consideration by nearby and international communities [32]. There are 5 primary strategies for inspecting air quality; aloof checking, dynamic (self-loader) examining, programmed point observing, photochemical and optical sensor frameworks, remote optical/long-way checking [8].

1.1 Passive Monitoring: this approach utilizes dispersion tubes to retain a particular contamination from the encompassing air and no power supply is required for this approach; the dispersion tubes are typically screen for 2-4 weeks on end. However, the tubes are then sent to a research center for investigation to identify how much contamination they have recognized. [25]

1.2 Active (self-loader) testing: An analyzer is utilized as a part of this technique to pull the surrounding air through a channel for a set timeframe e.g. one channel for every day; the channels are then gathered and sent to a research facility for investigation to perceive how much contamination they have identified.[21]

1.3 Automatic point checking: Ambient air is pulled through an analyzer which perceives the picked gas and afterward computes its focus. Programmed locales screen poisons 24hours a day. Information is sent from the site specifically to a PC which implies it can be seen immediately. [4]

1.4 Photochemical and Optical Sensor framework: These are versatile checking instruments that can constantly screen a scope of contaminations [13]. The sensors are of low affectability and for the most part appropriate for distinguishing hotspots at roadsides and close point sources. Information can be downloaded to a PC and examined. [5]

1.5 Remote optical/Long-way checking: This technique for examining identifies contamination between a light source and an identifier which are put independently at a site. Ongoing estimations can be brought with this kind of examining. Information can be sent from the analyzer specifically to your PC which implies it can be seen in a split second. [22]

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These days most huge urban communities in Europe have procured an air quality reconnaissance system. Such a system is made out of a couple of static measuring stations, which permit a persistent observation of air pollutants at the station areas [14]. Pollutants data are gathered on a daily or hourly basis and used to figure an air quality data the ATMO data. This data educates the populace about air quality in their environment. In reply to a high rate of pollutants, agencies can take proactive measures on automobiles movement and on activities of some industries that release high volume of pollutants into the air thereby distorting the quality of air in the environment. [27]

In other to ensure that air pollution is mitigated, there is a need to put in place an effective system that will check the quality of air by monitoring the amount of pollutants that are being released into the air. This system will also consider ways to cut down activities that release a huge amount of these harmful gases or pollutants (SO_2, NO_2, PM_{10}, and O_3 etc.).[29] One of such systems is no doubt the use of Remote Sensing and the GIS (Geographic Information Systems) technique which proves to be more adequate for environmental monitoring [38].

2. Literature review

This chapter provides a perspective of what GIS implies and concentrates on literatures and investigation on how and manner the coming of Geographical Information Systems (GIS) has transform the process regarding environmental monitoring. It reviews previous research been carried out on environmental monitoring with the use of GIS innovation. [16]

2.1 What is GIS?

Geographic information system (or GIS) is a framework designed to gather, store, control, examine, oversee, and exhibit spatial or topographical information [39]. The acronym GIS is in some cases is use as geographic information science (GIS science) to cite to academic discipline that reviews geographic information systems and is a huge space within extensive academic training in geo-informatics.[17] It is connected to numerous operations and has numerous applications identified with engineering, planning, administration, transport/coordination, protection, telecommunications, including business. Every Earth stationed spatial earthly area and standard references ought to be significant to each other and eventually to a "genuine" physical area or degree. This key factor has basically for GIS has started to open new roads of scientific inquiry. [14]

2.2 GIS and environmental monitoring

The Improvement and presumption of geographical information system (GIS) approach in recent time has essentially extended the time of strategies methods for presentation monitoring. By making utilization of GIS, along these lines, the open door stays to build up extra modern measures of revealing new technology, which may perceive extra dependably included examples of pollutants that can occur in urban areas as reported by [11]. Furthermore, the dispersion modeling improves the real development of transport (hence in a few area with compound reactions) to regulate the concentration going with a specified measure of outflow sources. Moreover different systems and measurements are included as a region for presentation inspected stays uncertain. It looks at ten various assessment, six base on pointers and four on modelling strategies, as far as their capacity to predict yearly average (i.e. endless air contamination the study of disease transmission) PM_{10} pollutant crosswise over 52 monitoring locations in the United Kingdom (London).

Presently, there is an abundance of atmospheric synthesis satellite information for air quality (AQ) applications which has demonstrated important to environmental experts: nitrogen dioxide (NO_2), sulfur dioxide (SO_2), smelling salts (NH_3), carbon monoxide (CO), some unpredictable natural mixes (VOCs), and airborne optical profundity (AOD).[20]

2.3 Air pollution and monitoring

Air contamination in vast urban areas is among the trending issues to be addressed both by neighborhood and worldwide groups due the level of contaminations, which can have negative impact on human life. As air contamination is a main ecological hazard, by decreasing the levels of air contamination, nations will decrease the rate of ailment from respiratory contaminations, heart illness as well as lung cancer according [37]. The requirement needed to regulate exposure to air contaminants include the actions taken by public authorities and policy makers of regional, national and international levels. [6]. Trans limit and household air contamination is of major concern among the EU member states. In 2010, around 21% of EU urban populace had contact directly with PM_{10} above the normal standard set by European Environmental Agency [6]. The WHO, USEPA (U.S. Ecological Protection Agency) and EEA have set up a broad collection agency which sets up standard and goals for various air pollution, for example, PM10 (coarse particles), PM2.5 (fine particles) and O_3 [7] Recently study has been focused on investigation of provincial and intercontinental movement of air contaminant, for example, particulate matter (PM_{10}, 2.5), focuses to a requirement for extra information sources to examine air contamination in numerous measurements, both spatially and transiently. To solve this problem, earth finding from remote sensors can be an important instrument for observing air contamination because of their capacity to give finish and concise perspectives of extensive areas. In spite of the fact that air quality measuring stations have been set up in mostly urban areas, there has been an expanded need to build up more stations for recording the ground pollutants in most cases ground stations gives a way to cautioning people in general with respect to air quality. Therefore, ground measuring stations are confined and don't give adequate coverage to observing air contamination, since air quality is profoundly factor. [28] [31] the utilization of earth perceptions to measure air contamination in various topographical ranges, particularly urban areas, has gotten impressive consideration from analysts [32] [16] [18] [24] [25].

3.0 Materials and Methods

3.1 Source of Data

The data that were used for the study was obtained from the ground based stations in North Cyprus.

3.1 STUDY AREA AND GROUND DATA

Northern Cyprus is the Turkish side of the eastern Mediterranean island of Cyprus, partitioned between Turkey and Greece since the late 20th century North Nicosia is located within this coordinate 35°11′N 33°22′E / 35.183°N 33.367°E.

The ground based collection was carried out using automated weather station situated in the Turkish Republic of Northern Cyprus (TRNC). Two year data from 2012 to 2013 was collected for the study over the locations. There are 7 ground stations across the TRNC that record hourly/daily amount of air pollutants in the city.

The air pollutants that were recorded include: PM_{10} (daily), O_3 (hourly), NO_2 (hourly), and SO_2 (daily) but only PM_{10}, O_3, and NO_2 was analyzed in these thesis. On-site measurement of air pollutant parameters for O_3, NO_2, SO_2 and PM was employed. The data were collected from January 2012- December 2013 (period). The values of the pollutants are measured in the units below (μg/m^3). PM_{10} is being measured daily while O_3 and NO_2 are being recorded hourly.

Ground stations' data were obtained from Environmental Department of TRNC. All stations in Figure 1 that falls within same box gives same value, except for the once outside the pixel which happens to be only two stations Guzelyurt and Kalecik. In the course of this analysis, the missing data makes the average for each month or season differs after comparing the ground and satellite data.

3.2 Instrumentation of Campbell scientific automatic weather station

The ground station used at TRCN is shown below the was used to measured the ground base data for the analysis

Figure 1: Ground station in TRNC.

4.0 Results

Table 1: Monthly statistical analysis of PM_{10} and AOD for the period of 2012-2013 for winter months and each station

MONTHS	STATIONS	POLLUTANTS	MIN	MAX	MEAN	STDEV
DEC	KYRENIA	PM_{10}	12.7	90.2	41.31	18.62
		AOD	**0.03**	**0.25**	**0.11**	0.06
	FAMAGUSTA	PM_{10}	12.7	75.3	44.31	18.2
		AOD	0.03	0.25	0.11	0.06
	ALEVKAYASI	PM_{10}	**5.4**	**43.3**	16.83	**9.47**
		AOD	0.05	0.25	0.12	0.06
	GUZELYURT	PM_{10}	14.4	62.6	32.37	10.71
		AOD	0.03	**0.52**	0.13	0.06
	KALECIK	PM_{10}	11.3	61.6	**25.37**	11.57
		AOD	**0.06**	0.33	**0.13**	**0.07**
	NICOSIA	PM_{10}	**27**	**127.8**	**71.73**	**28.29**
		AOD	0.03	0.27	0.12	**0.06**
	KYRENIA	PM_{10}	11.8	**59.2**	36.48	13
		AOD	0.06	0.4	**0.16**	0.09
	FAMAGUSTA	PM_{10}	20.5	122.1	60.87	**27.26**

JAN		AOD	0.06	**0.4**	0.16	0.09
	ALEVKAYASI	PM_{10}	**4.1**	62.3	**18.85**	**5.53**
		AOD	0.06	0.41	0.17	**0.07**
	GUZELYURT	PM_{10}	10.9	123.7	36.98	10.35
		AOD	0.06	**0.86**	0.18	**0.18**
	KALECIK	PM_{10}	7.9	89.2	30.1	16.45
		AOD	**0.06**	0.47	**0.18**	0.1
	NICOSIA	PM_{10}	**24**	**128.3**	**71.52**	24.65
		AOD	0.06	0.41	0.18	0.09
FEB	KYRENIA	PM_{10}	10.9	**79.9**	41.4	**18.83**
		AOD	**0.08**	0.28	**0.15**	0.05
	FAMAGUSTA	PM_{10}	14.6	**180.3**	47.26	14.07
		AOD	0.05	**0.91**	0.2	0.05
	ALEVKAYASI	PM_{10}	**6.1**	89.8	**19.54**	7.7
		AOD	0.05	0.91	0.19	**0.05**
	GUZELYURT	PM_{10}	12.3	107.2	37.74	9.43
		AOD	**0.05**	1.19	0.21	0.05
	KALECIK	PM_{10}	11.6	111.6	37.59	**5.75**
		AOD	0.05	**1.1**	**0.25**	**0.12**
	NICOSIA	PM_{10}	**27.6**	132.1	**69.77**	29.2
		AOD	0.05	0.91	0.19	0.05

Table 2: Monthly statistical analysis of PM_{10} and AOD for the period of 2012-2013 for spring months and each station.

MONTHS	STATIONS	POLLUTANTS	MIN	MAX	MEAN	STDEV
	KYRENIA	PM_{10}	18.2	267.2	52.27	43.79
		AOD	**0.09**	0.62	0.24	**0.14**
	FAMAGUSTA	PM_{10}	18.4	216.6	45.41	29.62

MARCH		AOD	0.07	0.9	0.24	0.17
	ALEVKAYASI	PM_{10}	6.9	**118.6**	**22.9**	**21.76**
		AOD	0.07	0.9	**0.24**	0.17
	GUZELYURT	PM_{10}	12.2	**286.4**	45.32	41.82
		AOD	**0.06**	**1.82**	0.27	0.28
	KALECIK	PM_{10}	**14**	229.5	48.48	**46.56**
		AOD	0.06	1.66	**0.31**	**0.32**
	NICOSIA	PM_{10}	**27.8**	276.8	**73.57**	46.48
		AOD	0.07	**0.9**	0.24	0.17
APRIL	KYRENIA	PM_{10}	18.5	133.6	42	**18.79**
		AOD	0.07	**3.37**	0.44	0.5
	FAMAGUSTA	PM_{10}	**20.5**	129.5	42.28	20.85
		AOD	0.07	3.37	0.44	0.5
	ALEVKAYASI	PM_{10}	**8.1**	**272.6**	34.26	**42.61**
		AOD	**0.07**	3.37	0.42	**0.52**
	GUZELYURT	PM_{10}	18.5	239.6	46.57	38.62
		AOD	**0.08**	2.54	0.32	0.39
	KALECIK	PM_{10}	12.9	**101.5**	**31.65**	20.56
		AOD	0.07	**1.62**	**0.32**	**0.3**
	NICOSIA	PM_{10}	23.9	228.8	**60.05**	34.87
		AOD	0.07	3.37	0.44	0.5
MAY	KYRENIA	PM_{10}	12.1	132.8	43.98	**20.52**
		AOD	0.03	1.41	0.28	0.21
	FAMAGUSTA	PM_{10}	**16.1**	66.9	39.63	11.12
		AOD	0.03	1.41	0.28	0.21
	ALEVKAYASI	PM_{10}	**11.5**	**40.6**	**26.83**	**6.45**
		AOD	**0.03**	**1.41**	0.28	0.22
	GUZELYURT	PM_{10}	12.8	73.2	33.68	12.96
		AOD	0.04	**1.08**	**0.26**	0.22

	KALECIK	PM_{10}	12.3	62.8	35.26	11.99
		AOD	**0.1**	1.31	0.3	**0.22**
	NICOSIA	PM_{10}	16	**141.3**	**46.49**	20.09
		AOD	0.03	1.41	**0.28**	**0.21**

Table 3: Statistical analysis of PM_{10} and AOD for the period of 2012-2013, for summer months.

MONTHS	STATIONS	POLLUTANTS	MIN	MAX	MEAN	STDEV
JUNE	KYRENIA	PM_{10}	**12.4**	**63.9**	38.48	11.72
		AOD	**0.07**	**0.71**	0.27	**0.13**
	FAMAGUSTA	PM_{10}	15.7	96.4	42.57	14.55
		AOD	0.07	1.15	**0.3**	0.18
	ALEVKAYASI	PM_{10}	8.8	77	**24.58**	**10.84**
		AOD	0.07	1.15	0.29	0.18
	GUZELYURT	PM_{10}	13.7	**110.9**	36.37	**15.45**
		AOD	0.05	1.04	**0.22**	0.15
	KALECIK	PM_{10}	32.5	99.3	**51.19**	14.71
		AOD	**0.01**	**1.43**	0.26	**0.22**
	NICOSIA	PM_{10}	**18.9**	84.5	41.24	14.33
		AOD	0.07	1.15	0.29	0.18
JULY	KYRENIA	PM_{10}	17.6	72.8	41.75	11.84
		AOD	0.03	**0.98**	**0.29**	**0.17**
	FAMAGUSTA	PM_{10}	19.7	60.7	41.26	8.78
		AOD	0.03	0.98	0.29	0.17
	ALEVKAYASI	PM_{10}	**9.8**	**47.6**	**25.64**	9.57
		AOD	**0.03**	0.98	0.29	0.17
	GUZELYURT	PM_{10}	16.4	55.2	34.88	**8.11**

		AOD	0.05	0.57	**0.22**	**0.12**
	KALECIK	PM_{10}	24.4	70.7	**46.42**	**12.73**
		AOD	**0.07**	**0.54**	0.22	0.11
	NICOSIA	PM_{10}	**24.7**	**85.9**	44.02	10.74
		AOD	0.03	0.98	0.29	0.17
AUGUST	KYRENIA	PM_{10}	24.3	62.5	42.94	9.74
		AOD	**0.03**	**0.61**	**0.25**	0.11
	FAMAGUSTA	PM_{10}	**26.4**	65.3	**43.95**	9.54
		AOD	0.03	0.61	0.24	0.11
	ALEVKAYASI	PM_{10}	13.3	**45.6**	**26.31**	**6.9**
		AOD	0.03	0.61	0.24	0.11
	GUZELYURT	PM_{10}	**11.7**	53.2	34.7	8.57
		AOD	0.06	**0.4**	**0.19**	**0.07**
	KALECIK	PM_{10}	19.8	66.6	40.75	11.06
		AOD	**0.07**	0.41	0.21	0.08
	NICOSIA	PM_{10}	20	**68**	42.32	**11.31**
		AOD	0.03	0.61	0.24	**0.12**

Table 4: Monthlystatistical analysis of PM_{10} and AOD for the period of 2012-2013 for autumn months and each station.

MONTHS	STATIONS	POLLUTANTS	MIN	MAX	MEAN	STDEV
SEPTEMBER	KYRENIA	PM_{10}	26.9	68.9	41.55	7.85
		AOD	**0.08**	**0.53**	**0.21**	0.09
	FAMAGUSTA	PM_{10}	**29.3**	58.8	42.72	6.85
		AOD	0.08	0.53	0.21	0.09
	ALEVKAYASI	PM_{10}	**14.6**	**41.9**	**24.07**	**6.83**
		AOD	0.08	0.53	0.21	**0.09**
	GUZELYURT	PM_{10}	23.8	68.2	39.73	9.15

		AOD	**0.06**	0.39	**0.16**	0.07
	KALECIK	PM_{10}	21.4	55.4	32.88	7.59
		AOD	0.07	**0.31**	0.16	**0.05**
	NICOSIA	PM_{10}	15.8	**98.5**	**48.86**	**16.63**
		AOD	0.08	0.41	0.2	0.08
OCTOBER	KYRENIA	PM_{10}	18.5	**382.4**	58.01	52.34
		AOD	0.04	**0.79**	**0.19**	0.14
	FAMAGUSTA	PM_{10}	17.5	211.4	46.91	32.58
		AOD	0.04	0.79	0.19	0.14
	ALEVKAYASI	PM_{10}	**7.4**	337.6	**29.56**	43.98
		AOD	0.04	0.79	0.18	0.13
	GUZELYURT	PM_{10}	14.6	**83.6**	34.86	**13.88**
			0.03	**0.4**	**0.13**	**0.09**
	KALECIK	PM_{10}	13	373	41.93	**60.93**
		AOD	0.04	1.2	0.18	**0.17**
	NICOSIA	PM_{10}	**19.6**	354.6	**64.77**	50.51
		AOD	0.04	0.79	0.19	0.14
NOVEMBER	KYRENIA	PM_{10}	13	109.3	59.93	20.37
		AOD	0.06	**0.55**	**0.23**	**0.11**
	FAMAGUSTA	PM_{10}	18.7	106.1	62.32	21.4
		AOD	0.06	0.55	0.23	0.11
	ALEVKAYASI	PM_{10}	**4.6**	**57**	**27.67**	**14.94**
		AOD	0.06	0.55	0.23	0.11
	GUZELYURT	PM_{10}	15.8	86.9	44.63	17.16
		AOD	**0.03**	**0.58**	**0.2**	0.11
	KALECIK	PM_{10}	9.7	84.8	38.5	20.12
		AOD	**0.07**	0.57	0.23	**0.12**
	NICOSIA	PM_{10}	**24.3**	**136.2**	**74.15**	**25.73**
		AOD	0.06	0.55	0.23	0.11

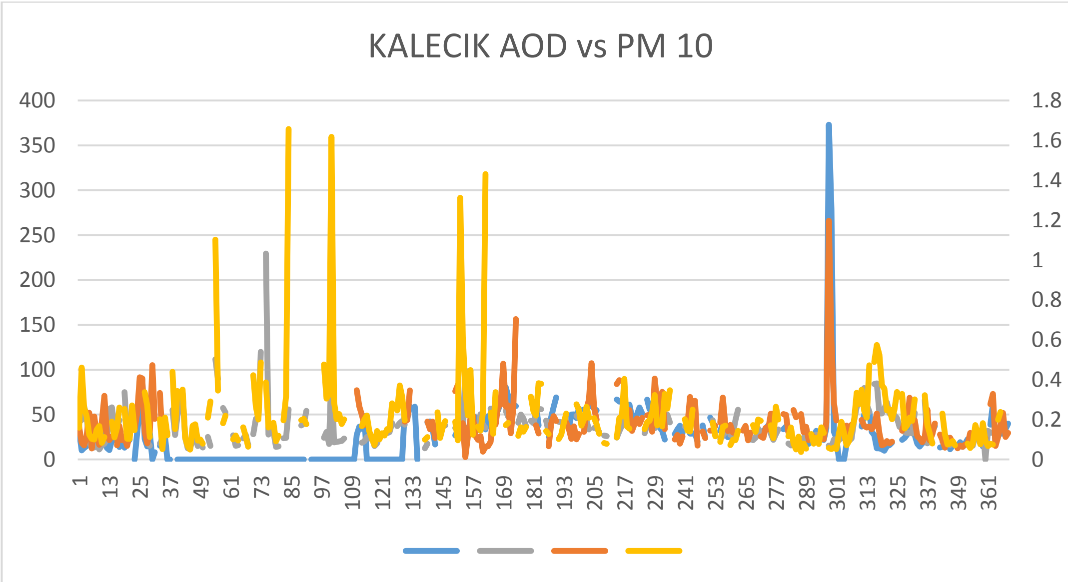

Figure 1: Time series of PM10 and AOD for Kalecik (2012-2013)

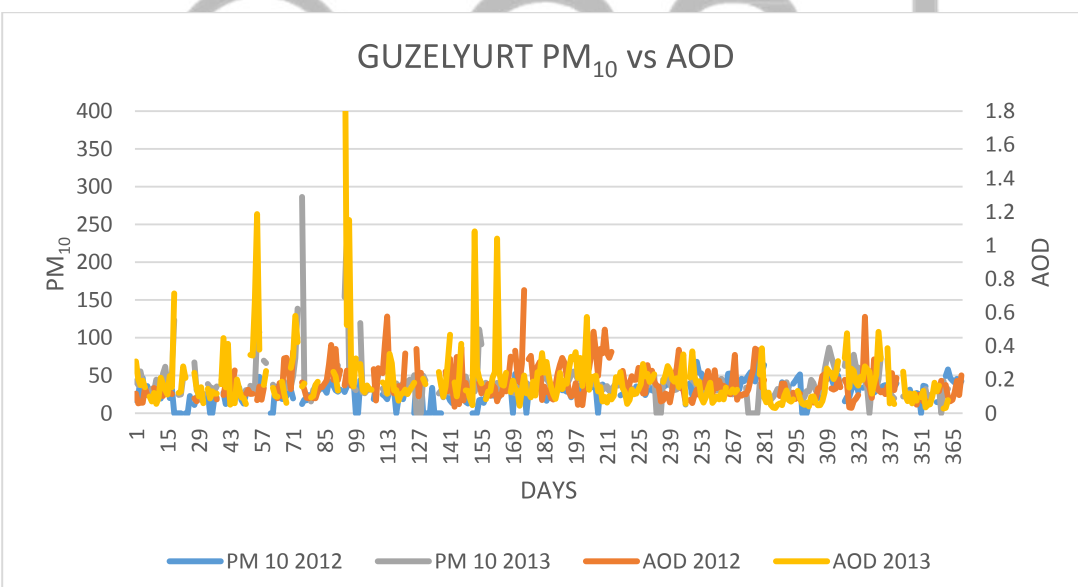

Figure 2: Time series of PM10 and AOD Guzelyurt (2012-2013**)**

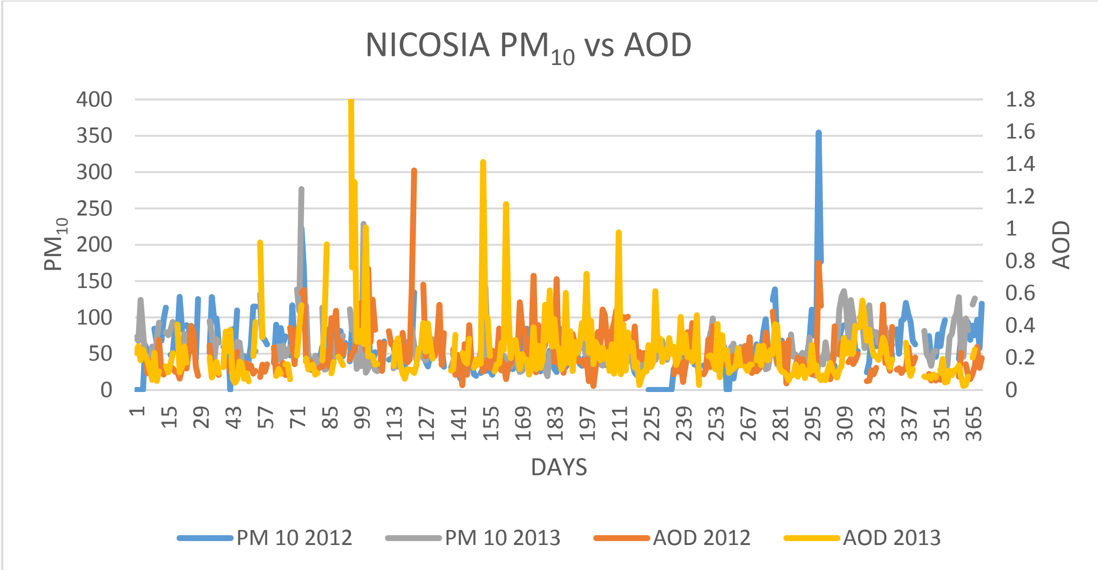

Figure 3: Time series of PM10 and AOD Nicosia (2012-2013)

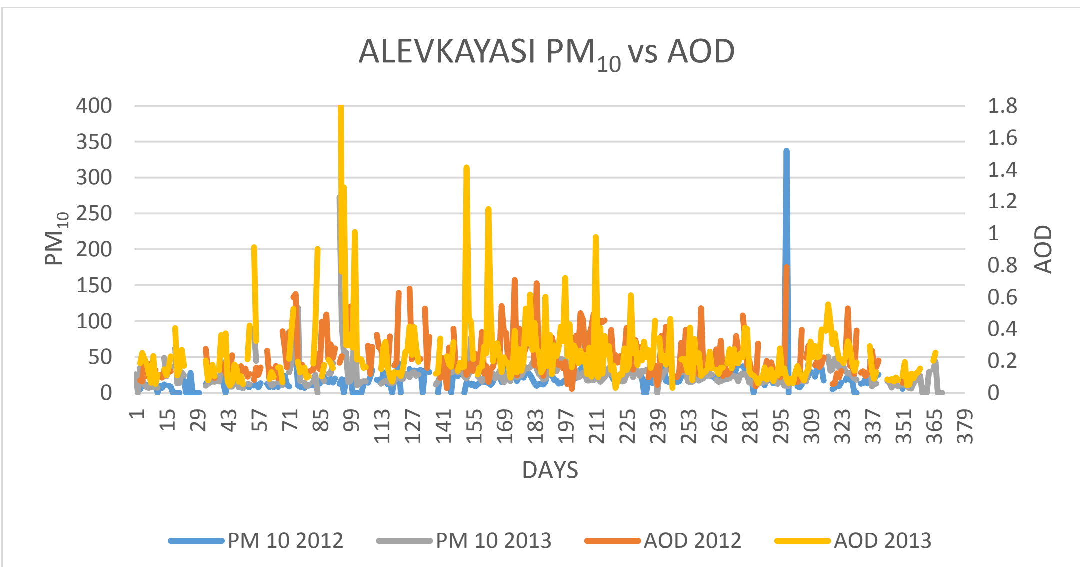

Figure 4: Time series of PM10 and AOD Alevkayasi (2012-2013)

4.0 Discussion of Results

This details analysis of the results are presented here of PM_{10}, O_3 and NO_2 it gives the general over view of all the seasons in the north Cyprus. The standards in the area are as follows PM_{10} is 50 µg/m^3, O_3 is 240 µg/m^3 and NO_2 is 200 µg/m^3 while EU standard is PM_{10} is 50 µg/m^3, O_3 is 120 µg/m^3 and NO_2 is 200 µg/m^3. According to National Oceanic and Atmospheric Administration (NOAA), Earth System Research Laboratory the standard for AOD should from 0.1-0.15 is good weather while anything from 0.4 that means the concentration of dust is high and causes haze weather.

4.1 PM_{10} and AOD Analysis

The monthly statistical mean values of PM_{10} and AOD for the seven meteorological stations in TRNC; were presented monthly and also seasonally.

Generally, there is a wide range variation of PM_{10} in all the six stations (Famagusta, Kyrenia, Nicosia, Alevkayasi, Guzelyurt and Kalecik) in TRNC that was analyzed during the selected years (2012 and 2013). However, Teknecik station data was not available due some technical reasons related with the station in the period of years of the data collection. The highest mean value of PM_{10} is 74.15 μg/m^3 in the month of November at Nicosia station; virtually during winter season months (December, January and February) the values are all above 70 μg/m^3 unless in the month of February that has 69.77 μg/m^3. This values corresponds with similar studies of W.J Qu et al., 2010 in China; and reported that cities were grouped as zone and they obtained similar mean analysis values to this studies, were in the middle zone it was reported that the mean values were around 67 μg/m^3 and this varies with the other regions values in the northern zone and the southern zone which has higher value than the middle zone; furthermore the argues that, the reasons for that was the region has lower population and as such could have less PM_{10} concentration than the highly populated region. Nicosia has the highest mean value as stated above and this is related to the weather during winter where there is more heating of homes and offices and also pollution from vehicles which could lead to high combustion of fossil fuels as reported by (Li et al., 2008). There are low mean concentration of PM10 in the less populated regions of this studies such as Alevkayasi with 16.82 μg/m^3, 18.85 μg/m^3, and 19.53 μg/m^3 in December, January and February respectively. During spring season, Nicosia has 73.50 μg/m^3 in March and 60.05 μg/m^3 in April and 46.48 μg/m^3 in May, similarly 48.48 μg/m^3 and 51.11 μg/m^3 was recorded for Kalecik station in the month of March and June respectively. This could be probably due to dust events as reported by Wang et al., (2004). However, there is a drop PM_{10} concentration in each station during summer in all the region when compared to what is recorded in winter or autumn periods. Table 2; illustrates that Nicosia has the highest mean of 73.57 μg/m^3 in the month of March and 22.9 μg/m^3 still in March for PM_{10}. Meanwhile, the data obtained for AOD illustrates that 0.32 is the height value at Kalecik station in the month of March, while 0.24 for Alevkayasi as the lowest in the same month. Table 3; illustrates that Kalecik has the highest PM_{10} value with 51.19 μg/m^3 in Kalecik in the month of June and the lowest data of 24.58 μg/m^3 in Alevkayasi in the month of June. The highest AOD is 0.29 at Kyrenia station in the month of June as well as the lowest with 0.3 in Famagusta.

In Table 4; 64.77 μg/m^3 was documented as the highest mean value in Nicosia for the month of October, and 24.07 μg/m^3 as the lowest in Alevkayasi in September for PM10, and also AOD with 0.23 in Kyrenia in November, and 0.13 as the lowest in Guzelyurt in the month of October.

The time series graphs illustrates the yearly pix of the daily rise and fall of the pollutant across the year for PM_{10} and AOD.

5.0 Conclusion

Generally, the analysis presented in this research explains that the integration of ground observation and remote sensing technology (GIS) methods can be used to monitor the pollutant concentration in the air. Conclusion from this research have shown that satellite remote sensing and GIS methods can potentially be used by environmental manager and local authorities to continually monitor air quality (at micro-scale) of both urban and rural areas [2] [3].

Furthermore, PM_{10} and AOD gave strong correlation between the two products almost across all season. In addition, O_3 the ground observation and remote sensing gave a moderately good correlation but mostly weak correlation. These are the following recommendation for this analysis.

- More ground stations should be established cross (TRNC) to cover a very large area.
- The authorities should make sure that the ground station devices are always in good conditions to be able to record the pollutant (in terms of technical problem).
- Ground stations should have a device for recording total column data (vertically) for pollutant like NO_2.

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