Trends in pesticides use in a world metropolis, Istanbul

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Introduction

Turkey is still known as an agricultural country as almost 36% of its total land is arable land despite the industrialisation efforts in the developing period that accounts more significantly. Istanbul is the most crowded city of Turkey even though it shares only 1% of the whole land. Almost 1/6th of the total population resides in this ancient megacity whose present population is estimated to be over 12 million, (according to the final census of 1997, the registered population was 9,198,809 (SSI, 1997)). The megacity is situated around the Bosphorous that joins the Black Sea to the Sea of Marmara as seen in Figure 1. The two bridges on the Bosphorous connect Asia to Europe. Istanbul receives a significant amount of migrating population from the other parts of the country each year, which brings together certain environmental problems like illegal and rapid urbanisation, insufficient infrastructure, pollution of surface and groundwater as well as the seas surrounding the city. In spite of various problems the city is facing, as is the case in most of the other megacities of the world, Istanbul is the industrial, commercial and cultural centre of the country. The drinking water demand of the city is to a large extent (95%) supplied from 6 main water reservoirs, located on both sides of the city as shown in Figure 1. A minor amount of water is supplied from groundwater (5%). As the present situation indicates, the catchment areas of these existing reservoirs occupy approximately 40% of the city's land. However, this percentage is continuously increasing due to the great efforts paid by the Water and Sewerage Administration of Istanbul, (ISKI), to increase the number of reservoirs and to enlarge the catchment areas by transporting fresh water from other streams outside the city's borders.

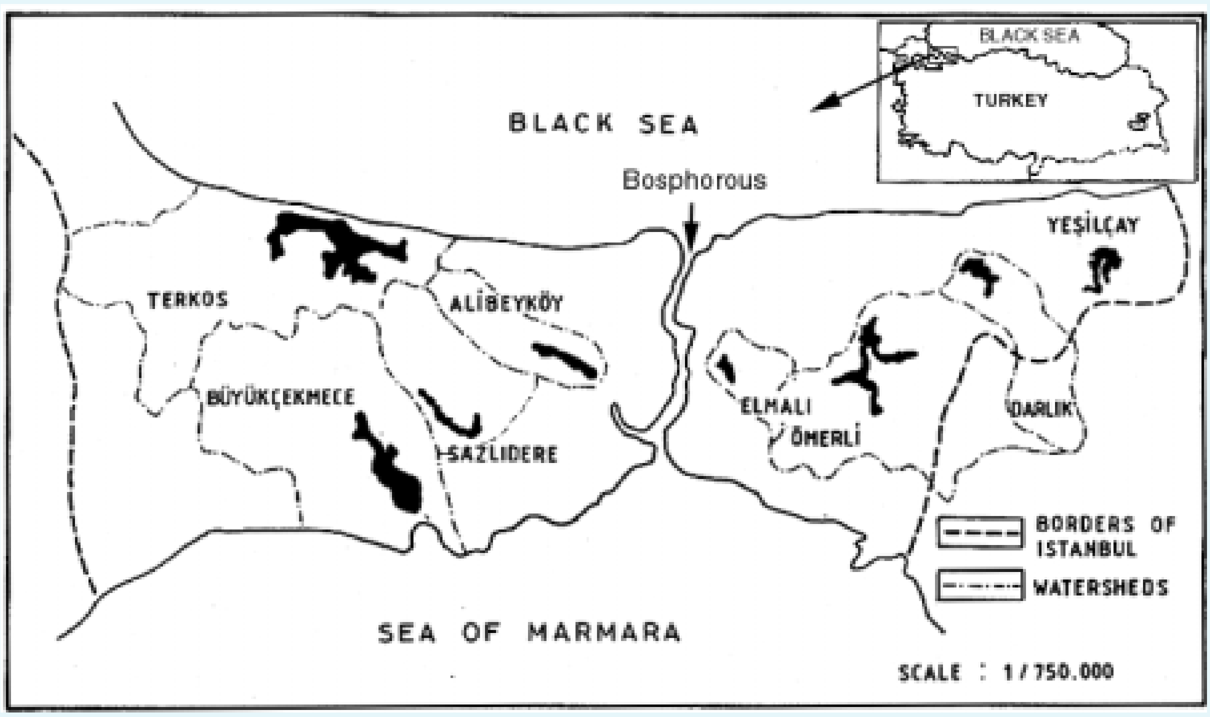

Figure 1. Drinking water catchment areas of Istanbul

The catchment areas of these reservoirs bear agricultural areas where mainly field crops are cultivated. As in most agricultural activities, fertilisers and pesticides are applied on land to increase crop productivity. However, according to the current basin regulations of ISKI (ISKI, 1998), agriculture is strictly forbidden in the absolute protection zone (0 - 300 m), whereas such activities are allowed in the further zones like short-range, medium-range and long-range zones (300-1,000 m; 1,000-2,000 m; 2,000 m - basin border) without using pesticides. In reality, it is observed that the bans have been ineffective so far. The activities within the catchment areas of the drinking water reservoirs of the megacity are monitored and managed by ISKI. The authorities are now on the way to cope with point sources of pollutants deteriorating the water quality of the reservoirs. Infrastructure facilities, collecting and treating the wastewater originating from the residential areas and industries within the catchment areas are rapidly being realised. Then, there comes the problem of diffuse sources of pollutants among which agricultural pollutants are of utmost importance. As widely known, pesticides contribute to environmental pollution because of their toxic character. Their residue in water constitutes a menace for human health because of their ability to penetrate and attack the fat tissues of living beings.

The aim of this study is to investigate the trends in pesticide use in the megacity and to compare the pesticide consumption values of years 1993 and 1998 especially in the catchment areas, following the description of the methodology used to calculate the consumption values. Hence, it is the authors wish to put forth and remind the authorities on the actual situation. The trend of pesticide use in the megacity will also be evaluated and discussed.

Methodology of calculating pesticide use in the Megacity

Pesticide consumption in the country is advised, ruled and monitored by the Ministry of Agriculture. The Ministry has an administration in almost every province. Thus, pesticide consumption records are to be obtained from the related provincial administration under the Ministry. Each province constitutes a number of districts, and pesticide consumption data are actually gathered on district basis. The Agricultural Administration of Istanbul Province collects pesticide data from each district having agricultural land (not all) and prepares annual records under pesticide categories of insecticides, fungicides, acaricides and herbicides. The State authorities of the Ministry of Agriculture follow monitoring to satisfy only agricultural needs and do not consider environmental aspects. Tables 1 and 2 give the total pesticide consumption values of the megacity for the years 1993 and 1998, respectively based on districts having agricultural land.

Table 1. Total pesticide consumption during the year 1993 in Istanbul (kg-lt/year)

PESTICIDE	Beykoz	B.Cekmece	Catalca	Eyup	Kartal	Sariyer	Silivri	Sile	**TOTAL**
Insecticide	8,727	3,623	15,856	2,865	2,163	294	7,211	26,836	**67,576**
Fungicide	3,075	3,710	6,603	3,782	1,198	1,030	21,491	1,716	**42,604**
Acaricide	2,227	4,712	35,737	420	1,465	208	200	23,267	**81,424**
Herbicide	0	12,875	28,859	2,150	900	0	71,550	2,000	**118,334**
TOTAL	**14,029**	**24,920**	**87,055**	**9,216**	**18,915**	**1,532**	**100,453**	**53,819**	**309,938**

Almost 60 different pesticides are applied in the megacity, out of which 17 are consumed in more than 1 tonne annually during the year 1998 (Yazgan and Kinaci, 2001). Table 3 gives the list of these typical pesticides that are consumed in more than 1 tonne annually in a decreasing order.

Table 2. Total pesticide consumption during the year 1998 in Istanbul (kg-lt/year)

PESTICIDE	Beykoz	B.Cekmece	Catalca	Eyup	Kartal	Sariyer	Silivri	Sile	**TOTAL**
Insecticide	7,828	3,454	11,585	2,856	2,907	264	2,008	25,983	**56,885**
Fungicide	794	2,967	7,680	2,513	2,795	1,425	1,588	1,115	**20,875**
Acaricide	536	259	5,995	2,304	2,319	209	51	656	**12,328**
Herbicide	200	6,635	2,000	4,800	320	0	38,150	600	**70,705**
TOTAL	**9,358**	**13,315**	**27,260**	**12,473**	**8,340**	**1,898**	**41,796**	**28,353**	**160,793**

Table 3. List of pesticides that are consumed in more than 1 tonne during 1998 in a decreasing order

Insecticides	Fungicides	Acaricides	Herbicides
Methiocarb	Mancozeb	Propargite	2-4 D amin
Chlorpyrifos-methyl	Propineb		Trifluraline
Dichlorvos	Myclobutanil		Dichlofob-methyl
Diazinon			
Carbaryl			
Malathion			
Phosalone			
Trichlorphon			
Oxydemeton-methyl			
DNOC			

Prior to mentioning on how the agricultural areas are distributed on a catchment area basis, it may be more enlightening to show Table 4 on the trends of unit pesticide usage in the megacity within the last decade.

Table 4. Agricultural land and unit pesticide loads within the last decade

Years	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Agricultural land (ha)	121,126	121,550	116,435	116,435	118,863	109,627	110,189	106,345	83,091	83,580	95,820
Unit pesticide consumption (kg-lt/ha)	4,167	3,667	3,510	3,880	2,780	3,046	2,260	2,320	2,500	2,590	2,677

As can be observed from Table 4, almost 100,000 ha of agricultural land is spared in the megacity whose total land area is 571,192 ha. On the average 17% of the city's land is arable land. The decrease in agricultural land within years is unfortunately due to conversion of agricultural land to residential areas. Unit pesticide applications slightly fluctuate with years, however, it is noticed that there is a decline especially after 1995. The reasons may be various. Depending on the occurrence of pests the consumption values vary, as well as with financial constraints, type of agriculture, climatic conditions, and especially by the limitations set by the local authorities (ISKI) within the context of the Basin Regulations. As depicted by Thyssen (1999), the sale of pesticides has generally decreased over the last decade in Europe due to various reasons. Turkey also reflects a similar trend. It is also important to note that large quantities of illegal imports are realised every year, which are not recognised by the official pesticide sales statistics, and so official figures may not reflect actual consumption and trends. However, this use of illegal amounts of pesticides is quite common in most of the European countries including Turkey. On the other hand, new and more efficient pesticides have been produced in the recent years replacing some of the old ones. The consumption of these new pesticides are even less with similar effect on the target organisms. The composition of some of the pesticides vary and even if used in small amounts their effect is again similar with lower environmental impact. Therefore, the observed decrease in pesticide use does not necessarily mean a decrease in crop production efficiency.

The amount of pesticides used in each catchment area is calculated by using the officially stated data belonging to districts and by making use of geographical data like basin borders, topographical situation, district borders, etc. The problem is that the district borders and the catchment area borders do not match, and it is a difficult task to transfer district data to basins. The distribution of pesticides among catchment areas is shown in Table 5. The total drainage areas and their land use distributions are given accordingly in Tables 6 and 7.

The Darlik reservoir is not shown in Figure 1 as recently its water is transferred to the Omerli reservoir. The Omerli reservoir supplies almost half of the drinking water demand of the city together with the water transferred from the Darlik reservoir. This is how the pesticide consumption values are calculated for each catchment area.

A similar study was conducted by Tanik *et al.*, (1999) on the impact of pesticide consumption on water quality of the reservoirs in terms of toxicological impacts.

Table 5. The distribution of pesticides among catchments areas of Istanbul

Catchment areas	Distribution of pesticides
B.Cekmece	= 3/5 B.Cekmece + 1 Catalca + 1 Silivri
Terkos	= 1/5 B.Cekmece + 1 Catalca + 1 Silivri
Sazlidere	= 1/5 B.Cekmece
Alibey	= 3 Eyup + 1 Sariyer
Elmali	= 3 Beykoz
Ömerli	= 3 Kartal

Table 6. The total drainage areas of the reservoirs (Tanik *et al.*, 1999)

Area (km^2)	Terkos	B. Cekmece	Sazlidere	Alibeykoy	Omerli	Darlik	Elmali
Total area	619	621	150	160	600	207	76
Reservoir area	31.8	28.5	11.8	3.8	20	5.8	4

Table 7. The present land use distribution of the reservoirs (Tanik *et al.*, 1999)

Land use (%)	Terkos	B. Cekmece	Sazlidere	Alibeykoy	Omerli	Darlik	Elmali
Forests & meadows	77	21	73	68	51	72	42
Agricultural land	17	65	23	19	35	25	31
Residential areas	1	12	3	3	10	1	26

Comparison of pesticide consumption in 1993 and 1998 in the catchment areas

Tables 8 and 9 report the pesticide consumption values in the catchment areas during the years 1993 and 1998 respectively, which are calculated according to the methodology described above.

Table 8. Pesticide consumption in Istanbul during 1993

Pesticides	Alibeykoy	B. Cekmece	Elmali	Omerli	Sazlidere	Terkos
Insecticides	2,222.3	13,707.5	6,545.3	1,622.3	724.7	12,258.2
Fungicides	3,351.2	16,273	2,306.2	898.2	742	9,416.2
Acaricides	366.8	20,795.7	1,669.9	10,990.7	942.4	18,860.9
Herbicides	1,612.5	57,929.5	-	675	2,575	34,892
TOTAL	**7,552.8**	**108,705.7**	**10,521.4**	**14,186.2**	**4,984.1**	**75,427.3**

Table 9. Pesticide consumption in Istanbul during 1998

Pesticides	Alibeykoy	B. Cekmece	Elmali	Omerli	Sazlidere	Terkos
Insecticides	2008,2	8877,4	5870,7	726,8	690,8	6983,4
Fungicides	2240,8	18913,8	595,5	952,8	593,3	5792
Acaricides	331	3178,2	402	1739,1	51,8	3062
Herbicides	1550	6635	34051,3	240	1327	30402
TOTAL	**6130**	**37604,4**	**40919,5**	**3658,7**	**2662,9**	**46239,4**

The change in % in pesticide consumption during 1998 compared to 1993 is shown in Table 10.

Table 10. The change in % in pesticide use during 1998 compared to 1993

Pesticides	Alibeykoy	B. Cekmece	Elmali	Omerli	Sazlidere	Terkos
Insecticides	-10	-35	-10	-55	-5	-43
Fungicides	-33	+16	-74	+6	-20	-49
Acaricides	-2	-85	-76	-84	-95	-84
Herbicides	-4	-89		-64	-48	-13
OVERALL TREND	**-18.8**	**-65**	**+288.9**	**-74**	**-46.6**	**-38.8**

The Table presents a decreasing trend in pesticide consumption in almost every catchment area. As mentioned previously, there are various and different reasons for this trend even in the catchment areas of this megacity. It is actually not correct to determine the trend of pesticides consumption in the catchment areas of the reservoirs just by gathering detailed data belonging to only 2-years with 5-years intervals. At this point, it is important to note that obtaining such statistical information from the local authorities was a very difficult and time-consuming job. The pesticides used in a district are recorded against the pests that appeared, and not totally recorded on a period basis like weeks and months. Thus, it took time to add the amounts of each pesticide in a district to reach a single figure. However Table 4, which is updated every year, helped a lot to conclude that there is a decreasing trend in pesticide use in the city. Concerning the catchment areas, one reason of the decline is the current basin regulation that has been ineffective so far, is now becoming more active as a result of serious control and banning of use.

An example of this situation is observed in the Terkos catchment area. As seen in Table 9, the Terkos catchment area is the leader of all in pesticide consumption during 1998. However, there is realised a decrease of approximately 40 % compared to 1993. In this specific area, rice growing is the typical agricultural activity. That is the main cause of using the highest amount of pesticide. In the other catchment areas mainly grains are produced. The Terkos reservoir has started to be also fed from the Istranca streams, transported by means of pipes and channels. Thus, ISKI has already strictly banned the rice-growing activities in the sense that high amounts of pesticides would easily be transferred to the reservoirs through the pipes and channels. That is the main reason of the declining effect to be referred to Terkos area. Another example is the Omerli catchment area. The overall decreasing trend is almost 74%. The cause of this fact is the conversion of agricultural areas to residential areas. Illegal settling, rapid urbanisation and insufficient infrastructure are the serious problems facing the region within the past 5 years. The Trans-European Motorway (TEM) is passing through the catchment area and this has highly attracted the attention, especially of the migrating population together with its proximity to industrial areas. The negative impact of urbanisation is highly observed in the water quality of the reservoir. Great efforts are being paid to the treatment facilities and to complete the sewage collectors and the wastewater treatment plants, (Baykal et al., 2000).

The trend observed in the Elmali catchment does not actually mean that the increasing trend is 3-folds of the year 1993. It is because the type of cultivation has changed. The farmers of the area have preferred to cultivate different crops in greenhouses, which highly required the use of herbicides. Therefore, the use of other pesticides like fungicides and acaricides reduced by 75% due to this change in production. In the other catchment areas, Alibeykoy, B. Cekmece and Sazlidere, there seems to be no change in agricultural activities or conversion of land to residential areas within 5 years. Compared to B. Cekmece and Sazlidere areas, no significant variations occurred at Alibeykoy region. At Sazlidere and B. Cekmece, declines of 46.6 and 65%, respectively, is due to a typical reduction in the use of pesticides as is the case in most of the Northern and Eastern European countries. Another effective factor is the Basin Regulations forbidding the use of pesticides in the catchment areas.

As previously mentioned, pesticide loading per unit volume of reservoir water is a criterion to indicate the probable pesticide loads that might appear in the water. Table 11 states the unit pesticide use and related loading per unit volume of the reservoir water for each catchment area.

Table 11. Unit pesticide use in the catchment areas and pesticide loading per unit volume of reservoir water (Kinaci &Yazgan, 2000)

	Alibeykoy	B. Cekmece	Elmali	Omerli	Sazlidere	Terkos
Pesticide use (kg-lt/ha)	2.7	1.1	0.9	0.2	0.2	3.4
Pesticide loading / volume of reservoir water (mg/m^3)	228	233	242	20	24	231

The characteristics of the reservoir and current agricultural land are taken into account during the preparation of this Table. Hence, it is depicted that unit pesticide use based on 1998 data (average unit consumption is 2,5 kg-lt./ha in the megacity Istanbul during 1998) in the Terkos area is quite high as expected, followed by Alibeykoy that lies at around the city's average unit application. At the other catchment areas, it is easily seen that the declining trend highly decreased the unit uses as expected. Pesticides after being applied on land, undergo a series of complex reactions which are highly affected by the properties of the pesticide, climatic conditions, soil characteristics, etc. Determination of their fate till they reach a water body through surface run-off or by leaching through soil is a difficult task to deal with. Such recent studies on estimating their fate either on soil and/or in water have started to be dealt with, (Tanik *et al.*, 2000). In this study, pesticide loading per unit volume of reservoir water is calculated without considering the probable reactions that might occur during transportation from the land to the water environment. The purpose of giving such a rough ratio is just to give an idea and even an order of magnitude on the loads that might reach the water without undergoing any reactions and also to point out the fact that the volume of the water body is of almost equal importance as well as the land area devoted to agricultural activities. Hence, the significance of reservoir volumes is emphasised. Similar loading is calculated for the reservoirs B.Cekmece, Terkos, Alibeykoy and Elmali, even though the unit pesticide uses are different. In spite of low pesticide usage in B. Cekmece and Elmali, loading in the water is found to be higher compared to the others. The Omerli reservoir and its catchment area, as mentioned previously, suffers from many environmental problems, however, it seems that the least amount of pesticide loading is to be achieved in this specific reservoir. A similar situation is also reflected in the Sazlidere reservoir.

Conclusions and recommendations

Turkey, as a developing country, is at a stage to cope with point sources of pollutants rather than dealing with diffuse sources of pollutants. Among the diffuse sources of pollutants, especially agricultural pollutants like pesticides and fertilisers are the dominant sources in the sense that agriculture is still a way of living in the country as 36% of its total land is arable land. The megacity Istanbul, with a population over 12 million supplies its drinking water demand from surface water reservoirs whose part of the catchment areas are spared to agricultural activities. The basin regulations state the bans of not using pesticides in the various zones of the catchment areas, which contradicts with the actual situation. However, within a 5 years period, it is seen that a decreasing trend in the use of pesticides appears based on different reasons specific for each catchment area. After solving the infrastructure problems, the authorities will come across with the problem of agricultural pollutants threatening the soil and water environments. Before it is too late, protective measures must be taken and put in operation together with proper and effective monitoring programme. Till now, the ineffective monitoring led to contradictions with the actual application of the stated regulations. The purpose of this study was to put forth the present situation in the application of pesticides in this world metropolis, and to compare the usage within years, to come up with a trend by inserting the officially recorded data. It is important to note here that, the decreasing trend caught in Turkey and in Istanbul is in full correlation with the situation in most of the European countries.

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