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Full Length Research Paper

The location of manure accumulated in cattle livestock barns and its interaction with the environment

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Manure, which is accumulated in cattle livestock barns, is regarded as serious waste if it is not stored properly. In order to avoid such problems, the manure should be stored in a closed and leak-proof environment. This study was conducted via the use of a questionnaire in Izmir, Odemis, Turkey. A stratified random sampling method was used in order to determine the number of enterprises associated with the questionnaire. The study was conducted by calculating the number of enterprises to be administered questionnaires at 95% confidence interval and 5% error. The purpose of this study was to determine the environmental situation of the accumulated manure in cattle barns. A trial was made to determine the manure storage periods, the distance to the other enterprises and settlements, and the distances of any water sources such as: lakes, rivers, creeks, irrigation canals, drainage channels, etc., in animal barns and then they were compared with the standard distances for project criteria. When compared to the standard distances for project criteria, it was observed that the obtained values were not suitable, and it was concluded that the degree of pollution increased with the increase in the storage time of the accumulated manure in open areas without any measure.

Key words: Barn, environment, manure, pollution, water resources.

INTRODUCTION

The number of total agricultural enterprises is 3,022,127 units in all the villages and districts of Turkey with a population of less than 5000. According to the results of the research, 5% of these enterprises are on animal production, 37.2% are on plant production and 62.3% are on both. There are 10,946,239 units of cattle, 29,568,152 units of sheep and 249,043,739 pieces of poultry in Turkey. If accumulated manure is not controlled and stored under appropriate circumstances in animal barns, it will lead to undesirable results associated with the environment and even a valuable material for soil will be harmful in this situation. Therefore, uncontrolled manure storage must be stopped and the use of manure in agricultural lands, or for any other purposes should be done consciously to prevent pollution.

When manure and urine are used together in agricultural enterprises, they will preserve the balance of soil in terms of organic substances and increase the vegetable production. However, overuse of manure and urine to improve the physical structure of the soil and support the crop production will negatively affect the amount of production, product quality, soil structure, ground and surface waters. Previously, the problems faced by using manures in grassland or farmland were neglected, but today, they have resulted into a new problem (Ergul, 1989; Karaman, 2005). Due to the negative effect associated with the production, the animal manure can damage the environment and public health. If the animal manure is not fully controlled, it can lead to diseases carried by food and water. The water-borne diseases can occur because of mixing the polluted water with the main system or irrigation water sources. The food-borne diseases occur with the fertilization of vegetables and fruits depending on the appropriate handling and accumulation of the manure (Anonymous, 2010a).

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The disease-causing microorganisms in manure can have an effect on animal and human health during waste management. Microorganisms can be transmitted directly or via rivers and drinking-water sources as a result of land application of manure. In addition, the solid and liquid manure can also be discharged into a river directly; thus, leakage to the ground water resources from the manure storage and excessive use of manure leads to pollution of groundwater and surface water sources. The land application of excessive amounts of manure causes water pollution, compaction of soil pores, shell binding of the surface of the soil and it has a negative impact on the physical properties of the soil. This type of soil inhibits the plant growth. Moreover, excessive manure application adversely affects the balance of plant nutrients in the soil (Olgun and Polat, 2005).

Fertilizers are commonly used in agricultural production, and in particular, chemical fertilizers have a significant effect on water pollution. Mainly, nitrate contamination of water resources is the most underlined factor among the environmental effects caused by fertilizers, because NO_3 portion in the fertilizers for agricultural production has been increasing over the years and because NO_3 has been accumulated in soils. The amount of accumulated NO_3 is dependent on environmental factors; as such, accumulated NO_3 moves to the deeper horizons of the soil and some of it could reach groundwater resources. Nonetheless, there are many studies in literature, considering water contamination caused by nitrogen in the fertilizers (Kaplan et al., 1999).

The aim of this study was to determine the appropriate storage conditions of accumulated manure in the animal barns in order to compare them with the suggested distances of water sources, neighboring businesses and settlement.

MATERIALS AND METHODS

This study was performed in Odemis, a province in the city of Izmir in Turkey, where the cattle husbandry farms were found in abundance. Therefore, a questionnaire form was prepared to collect data about the location of the manure storage and environmental contaminations. The number of surveyed farms, which is appropriate for this study, was determined by using the farmer database of the Agricultural Office of Izmir City. The Neyman method of the stratified random sampling technique was applied in the selection of the representative farms as follows (Yamane, 2001):

$$n = \frac{\sum (Nh Sh)^2}{N^2 D^2 + \sum Nh Sh^2}$$

Where, n is the sample size; Nh is the number of farms on h^{th} layer; N is the number of farms in the population; Sh is standard deviation of the number of animals per farm; Sh^2 is the variance of h^{th} layer; and D^2 is expressed as $(d/t)^2$, where d is the precision of (x-X) and t is the reliability coefficient of 1.96, which represent 95% reliability.

The number of farms was calculated by the aforementioned formula as 127, with 95% confidence interval and 5% error. The location of manure storage and interactions of the environment were investigated for 127 farms. The data collected by the questionnaire consisted of the time of the storage period (days), the distance of the manure storage area (MSA) to the community areas and neighbouring farms, and the distance of MSA to any water resources like lakes, river, irrigation channel, drainage channel, etc. However, these values have been compared with those suggested in the literature.

Chi-square test

The idea behind this test depends on equal portioning of the probability of the population function, which was calculated and the development of a histogram of samples within these portions. However, the histogram of the samples and population that were established by the portions are same as the portion of the samples when compared together. There are two different diverse chi square tests: equal distance portion and equal area portion tests (Kottegoda, 1980; Topaloglu et al., 2003).

The chi square test was used to determine the level of relation between: (i) the surveyed farmers' educational level and manure storage time, (ii) the farmers' educational level and the distance of the farms to the neighbouring and community areas, and (iii) the farmers' educational level and the distance of the farms to any water resources, such as: lake, river, irrigation channel, drainage channel, etc.

RESULTS

A large amount of manure is produced in areas where there is extensive animal production. When the manure produced is stored randomly, nutrient elements are transported to the water resources; especially nitrogen, which contaminates surface water, increases eutrophication and algae development, and damages both ecosystems in wetland and aquatic life (Girosso et al., 1998; Davis et al., 2002). In addition, fecal bacteria inside manure cause infectious diseases such as typhoid fever, dysentery and hepatitis via contaminated surface and ground waters. If the surface water is used as drinking water or for swimming, it will be very risky for human health (Grisso et al., 1998).

To avoid the unfavourable circumstances in the foregoing, the manure obtained from animal shelters must be stored in the areas having high impermeability in a controlled manner, but not randomly. Storing large amounts of manure in open areas not only reduces its quality but also causes environmental problems such as odour and sight pollution. Previous studies showed that the most significant pollution in enterprises is odour and sight pollution. Odour of manure, stored in open areas, could be felt in a distance of 400 m in normal conditions. This distance gets even larger in poultry manure. Humans could feel the odour of manure on the open fields from a distance of approximately 2000 m (Yaldiz, 2004). As a result, it is reported that when classifying animal shelter, manure storage facilities are generally neglected; moreover, even in some regions, these units are never planned (Atilgan, 1994; Mutlu, 1999; Yilmaz, 2001; Erkan, 2005; Atilgan et al., 2006). However, manure, which used to be considered as waste, will be

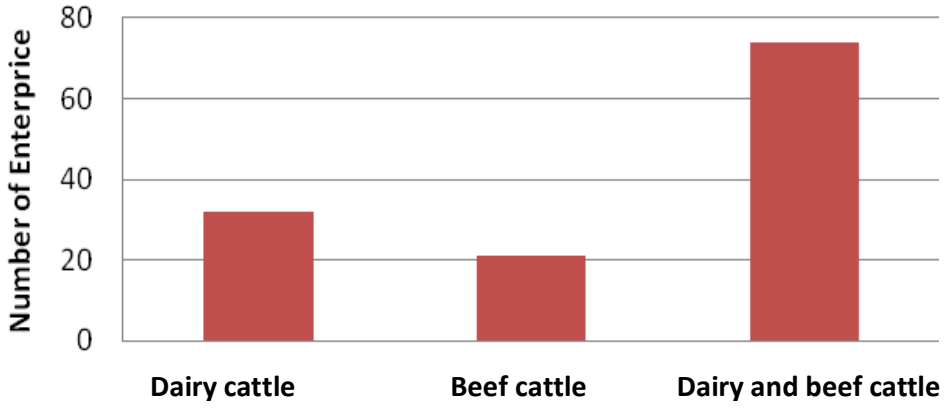

Figure 1. Types of production systems of surveyed farms.

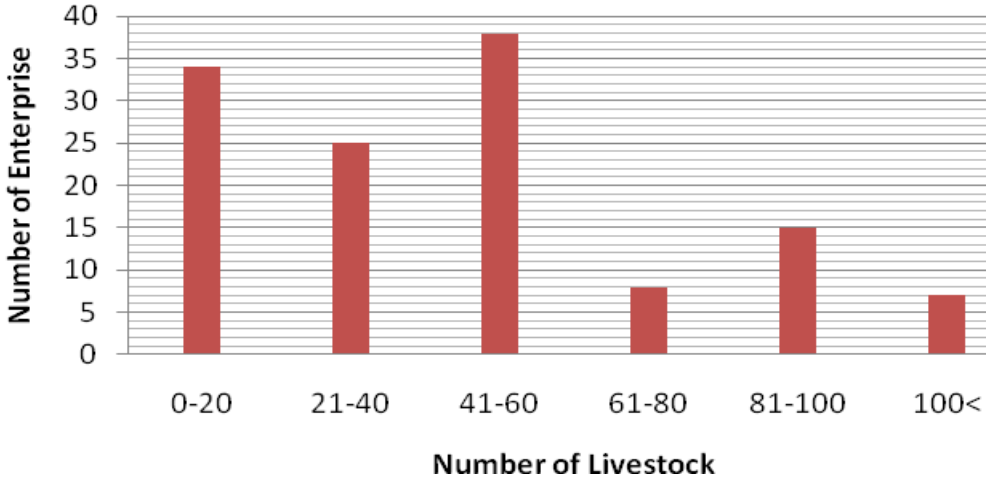

Figure 2. The distribution of animal numbers of the surveyed farms.

the largest nutrient source in plant production with planning manure storage areas in barns (Gilay et al., 2001; Davis et al., 2002). Thus, the amount of fertilizer input from producers will reduce. If proper attention is shown in the formation, progress and storage stage of manure and in the completion of the planning criteria that are acknowledged as a result of the research, it will be possible to access the most efficient manure method from manure material that appeared as a problem in barns. Otherwise, if manure piles, which accumulate and decompose in time, are stored in inappropriate conditions, we will confront not only a polluted environment and water supplies threatening human and animal health, but also odour and sight pollution.

DISCUSSION

The study was carried out in 127 livestock enterprises in Odemis town of Izmir city. The farms consisted of dairy cattle farms (25.2%), cattle farms (16.5%) and both dairy cattle and cattle farms (58.3%) making a total of 127 farms in the surveyed Odemis district (Figure 1).

According to the data showing the capacities of husbandry, 76.3% of the total farms were between 1 and 60 animals per farm. Figure 2 shows the distribution of the number of animals per farm.

Storage time

It has been suggested that manure storage time in the barns is 45 days for moderate climate and up to 210 days for cold climate (Anonymous, 1996). However, the manure accumulates in the open areas without any measure in all the surveyed enterprises. Therefore, the the surveyed enterprises (Figure 3).

There are no reliable data on total manure production

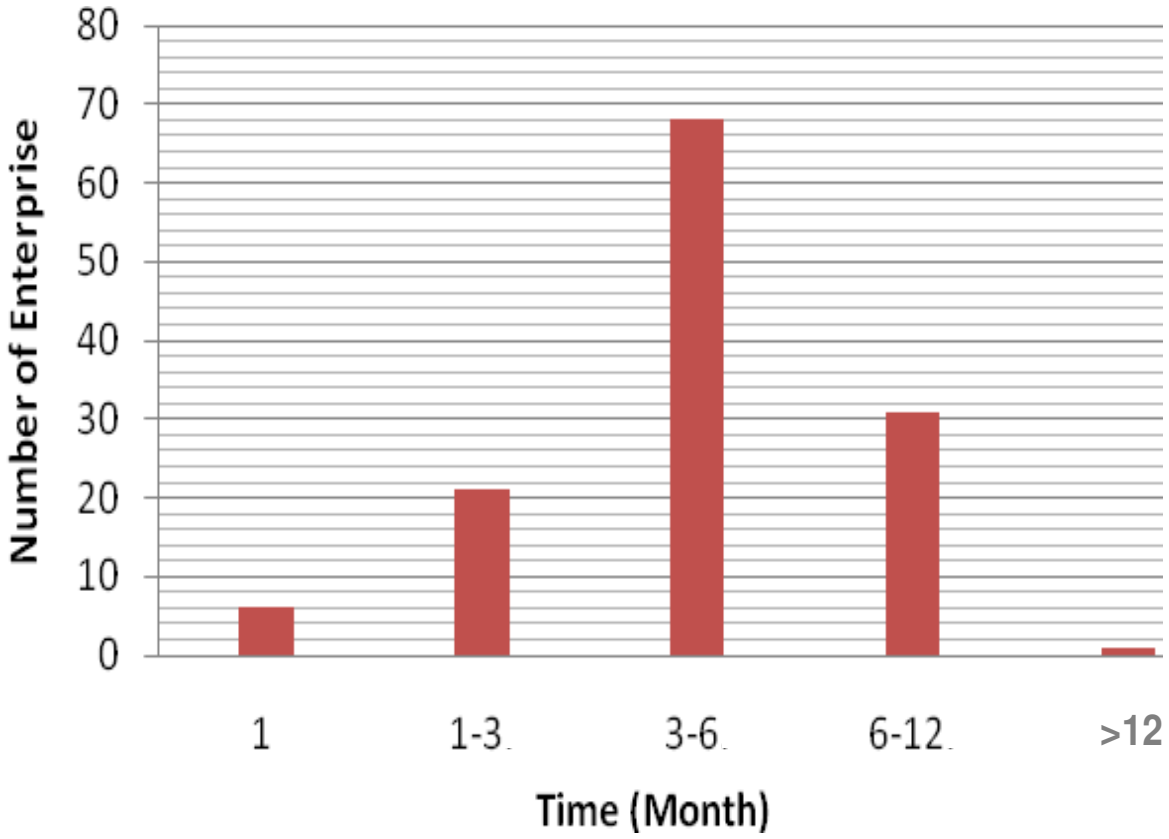

Figure 3. Manure storage time of the surveyed farms.

in Turkey. In particular, for sheep and cattle farms, accumulation of manure is not possible because the pasture period of animals within a year is not long. Given the period of animals' stay in the barns, the amount is estimated to be 82 million ton of the accumulated manure per year in Turkey. A large part of the accumulated manure (81%) is obtained from cattle and poultry enterprises. 75% of this manure is used as fuel in rural areas and 25% is used in agricultural production (Olgun and Polat, 2005). It is predicted that 20 million tonnes of manure will be stored until they will be ready for use (idle position). Although it is recommended that the manure should be stored for a certain time, in fact, the storage time is dependent on the amount of manure and climate of the area (Nicholson et al., 2004). When manure is stored in unsuitable conditions, such as in rainy weather, the pollutants in it reach the surface and underground water sources via runoff and deep infiltration. There are four basic pollutant elements in manure and they are: nitrogen, phosphorus, microorganisms and organic material. Thus, the aforementioned contamination factors are considered as a potential risk for both underground and surface water resources (Olgun and Polat, 2005; Anonymous, 2010b). Therefore, measures should be taken in case of manure storage in the open areas (Johson and Eckerty, 1995; Camberato et al., 1996).

Distance of MSA

While assessing the current state of animal manure in barns, there are certain factors associated with human, animal and environmental health that should be taken into account carefully. The most important factor is the distance of MSA to the settlement areas. The distance between the animal barns and the settlement areas in the 121 farms (95.2%) was found to be less than 1000 m in the surveyed enterprises (Figure 4). However, researchers suggest that animal barns should be built at least 1600 m away from settlement areas (Erkan, 2005; Atilgan et al., 2006), but majority of the farms did not obey the standard regulations associated with the distance of the MSA to the settlement areas. As a result of these studies, the distance values between animal enterprises and the settlement areas are given in Figure 4, while the relationship between the piles of manure with the neighbouring businesses is shown in Figure 5. As shown in Figure 5, almost 93% of the surveyed farms have a distance of less than 100 m from their MSA to the neighbouring farms. This will cause health problems for animals and workers in agricultural enterprises and environmental problems as well. Liang and Van Devander (2010) proposed that the minimum distance of MSA to the nearest neighbouring farm should be 150 m.

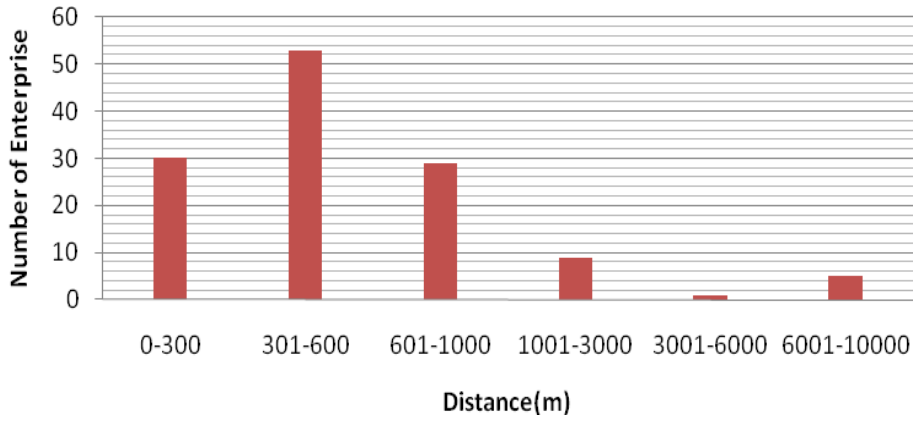

Figure 4. Distance of farms to the nearest community areas.

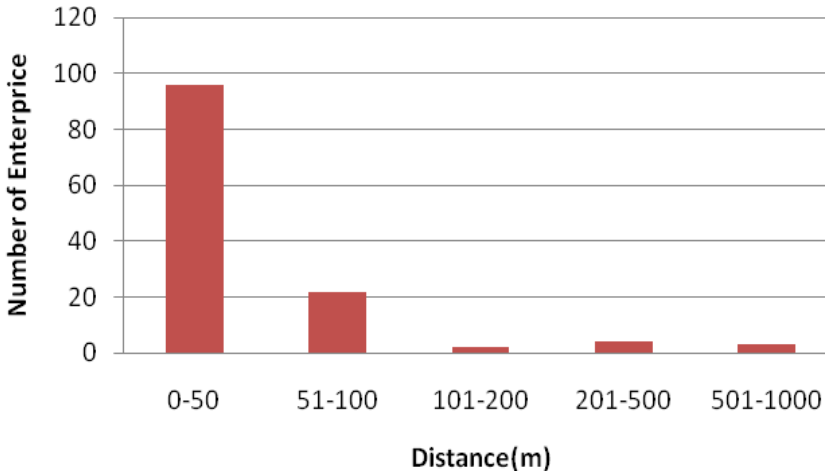

Figure 5. Distance of MSA to neighbouring farms.

For the bigger farms that have more than 600 beef cattle or 430 dairy cattle, the distance of manure pile should be at least 450 m from the neighbouring farms. In addition, the distance of MSA to the water resources is a very important criterion for environmental risk assessment. If the manure reaches the water resources or lake, it can be a risk factor not only for human and animal health, but also for the environment. The distance of MSA to the water resources, lake and river is shown in Figures 6 and 7. The literature suggests that the distance of MSA must, at least, be 50 and 300 m to the water surface and water resources (lake), respectively (Alagoz et al., 1996; Cayley et al., 2004; Karaman, 2005). The distance of the surveyed farms' MSA to the flowing water resources such as river, stream and irrigation channel is shown in Figure 7. According to Figure 7, the distance of MSA to water resources was between 1 and 100 m in the farms (101 farms) in whole, while it was less than 50 m in 65 farms. Nevertheless, it has been suggested that the distance of MSA must be at least 100 m for the flowing water source (Alagoz et al., 1996; Mutlu, 1999; Cayley et al., 2004; Karaman, 2005). This study shows that there was a considerable difference between the suggested values and research findings on the MSA distances to the water resources.

Manure occurrence in livestock could also be harmful to human health. If the manure cannot be controlled completely, or disposed off properly, it could cause diseases transported by food and water. Water contamination by animal manure can lead to various diseases by reaching drinking water resources or irrigation channels (Anonymous, 2010a).

The contaminants found commonly in underground water resources are nitrogen compounds (nitrate, nitrite and ammonia), phosphates, heavy metals, poison compounds, organic materials and microorganisms. Nitrate concentrations in underground water resources have been increased by agricultural operations and improper animal waste management techniques. Nitrogen compounds in surface waters can be of natural

or human origin. Human originated nitrogen compounds such as some chemical wastes, slaughterhouse wastes, municipal solid wastes and manures used in agriculture, create significant problems if carried by rain and drainage waters. Nitrogen compounds in the water can lead to eutrophication and oxygen balance and toxicity problems (Yalcin et al., 2004).

In this study, the educational levels of farmers were investigated. It can be seen from Figure 8 that 74 farmers (58.3%) were elementary school graduates, 40 (31.5%) were high school graduates, and 13 (10.2%) had bachelor's degree from different universities.

Interactions of the variables

The interactions of the variables were investigated via chi-square test. Two directional tables were prepared using the survey data and then the chi-square statistics were calculated. According to the results of the chi-square test, there was no relation between the distances of the enterprises from the settlement area and the educational level of farmers. The chi-square test statistics were calculated as 10,752 and it was not important from the statistical point of view. Additionally, chi-square calculation of the interaction between educational level of farmers and distance of the MSA to the neighbouring farms showed that these variables are independent with a value of 4.171. Similarly, the relationship between educational level and the distance of the MSA to water resources like streams, rivers or irrigational channels was found to be independent, with chi-square values of 4.002 and 5.677, respectively, and was as well as statistically not important at the same time.

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