



Sustainable water management and good sanitation through dry toilets: Case Study Ukraine

Yuliya Vystavna*

National Academy of Municipal Economy, Environmental Engineering
vul.Revolutsii 12, Kharkiv, 61002, Ukraine
e-mail: vystavna@ukr.net, vystavna@yahoo.com

Fabio Kaczala

University of Kalmar, Department of Technology
Norra Vägen 47, Kalmar, 39182, Sweden
e-mail: faka75@gmail.com

*Corresponding Author

Keywords: wastewater, sanitation, dry toilet, water management, efficiency.

ABSTRACT

Ukraine is one of the largest countries in Europe with population of about 48 million. However when comparing to other European countries, Ukraine is one of those suffering with shortage of water resources. At the moment, the daily water consumption throughout the urban territory is more than 500 liters per person. Moreover the leakage of wastewater during transportation, resulting in soil and groundwater pollution with organic compounds and nutrients, is known to occur in significant volumes and it is estimated to be more than 2 km³. It leads to insufficient sanitary conditions, bringing considerable negative outcomes for the human health. Furthermore, more than 10,500 km³ of wastewaters are contaminating surface water resources per year in Ukraine.

Households are known to be one of the most powerful water consumers on urbanized territories. Every day the big Ukrainian city, Kharkiv (1.5 million of people), consumes 200 million m³ water per year for households water supplying. About 2 million m³ of wastewater are discharged from low-stored dwelling sector (cottage type of buildings), 33 % of this amount is discharged by flush toilets.

The problem of surface water and groundwater pollution from wastewaters can be solved with the implementation of a non conventional water saving technology. Dry toilets in dwelling sector could bring significant benefits and improvements both for environmental contamination and public health.

The aim of this present work is to present an estimation of the water saving potential due the implementation of dry toilet systems in dwelling sectors of Ukraine. For this proposed work, an environmental engineering model, as well as a risk assessment approach and methods of economical analysis were used. The balanced model applied to water bodies' quality and water demand were developed using available secondary data. The regression parameters were determined for sanitary indicators of water



quality. Through the model it is possible to analyze the environmental impacts posed by the municipal water consumption and achieve the optimal level of public water supply based on water saving technologies.

As a result, it was estimated that the application of dry toilets throughout the Kharkiv cottages would reduce the water consumption on 500,000 m³ per year and consequently would bring considerable benefits providing environmental improvements as well as better sanitary conditions in Kharkiv region.

Economical and social criteria for dry toilets' implementation in cottages were developed based on economical factors and risk analysis of capital investments, reduction of water consumption payments, social opinion etc. Cost-benefit analysis of dry toilets' implementation has revealed really positive results in the municipal economy. Research results have shown that the society is not well involved in environmental problems or in the existing necessities for remediation and improvements. Therefore, it is important to emphasize the development of activities towards a better social perception of the current environmental problems, the necessity for the implementation of cost-effective solutions, and natural resources conservation. The enthusiasm of citizens can be transferred into concrete actions, which will increase economic growth while minimizing ecological and environmental harm at the same time.

INTRODUCTION

The sustainable use of natural and water resources in a municipal economy plays a key role in meeting economic, environmental and social objectives at both national and international levels. Inefficient water use indirectly leads to social, environmental and economical problems due to freshwater shortage, water pollution, environmental degradation, and over exploitation of both natural and energetic resources. Currently, prevailing conventional sanitation systems and concepts are based on the traditional water closet and flush toilets (WC-systems), basically a water wasting technology that represents a considerable pressure over the existing water and natural resources due to its requirement of high amounts of water for flushing. These systems can not be considered either environmental friendly or cost-effective solution in both industrialized and developing countries [1]. The implementation of water saving technologies could bring considerable solutions for the current water crises reaching desirable environmental and economical sustainability.

Use of dry toilets with the objective of water use minimization and consequent environmental and sanitary improvements has been recommended by some authors [2, 3]. These authors have observed that dry toilet systems are ecologically, hygienically and economically feasible, principally when well implemented, managed and operated. Reasonably, the implementation of waterless systems should be supported by decision-makers' strategy tools that are based on environmental and economical criteria and respective indicators.

The aim of the work is to analyze the potential of dry toilets implementation in Kharkiv city, Ukraine. The proposed indicators could be used as reliable data to assist decision-



makers in formulating their plans towards a sustainable society, using such an environmental friendly technology in the municipal strategy.

METHODS

The present work is based on available data from the municipal wastewater treatment plant of Kharkiv city as well as on the evaluation of technical, environmental, economic and social factors of water use and environmental pressure. The factors are investigated to use the methods of material input-output analysis, mathematical modeling, social survey, expert assessment. The principle of the criteria and indicators refer the Sustainable Water Industry Asset Resource Decisions (SWARD) assessment framework developed in the United Kingdom [4].

PUBLIC AND PRIVATE TOILETS USE: ECOLOGICAL SANITATION AND ENVIRONMENTAL PROBLEMS

Ukraine is one of the largest countries in Europe with population of about 48 million. Nevertheless, when comparing with other countries in Europe, Ukraine can be considered to have one of the worst scenarios regarding freshwater scarcity. The average availability of water resources for one person per year is 1700 m³, differently for example, from France with 4570 m³ per person per year and for Sweden with 24,000 m³ [5].

Kharkiv is the second largest city in Ukraine with approximately 1.5 million of inhabitants. The principal urban water supply is considered to be with the surface water approximately 85 % of the total amount. The Kharkiv region is not rich in water resources, which makes it important to focus in strategies towards sustainable management and efficient use of water.

Currently, households are the major consumers of water, demanding about 75 % of the total amount of water supplied by the municipal water company which corresponds to 375 litres per capita per day. Furthermore, approximately 70 % of this amount is used for flush toilets in buildings with water and wastewater service providing [6]. Every year, 1000 thousand m³ of treated wastewater are discharged into small water bodies from municipal wastewater treatment plants [7]. As a consequence, in current days the water quality throughout several Ukrainian rivers is not corresponding with Ukrainian Water Quality Standards by such indicators as ammonium, oil products, phenol, nitrates, nitrites, copper, total-iron, zinc and mineralization [7]. Among different rivers that have been loaded with wastewater from the municipal wastewater treatment plant at Kharkiv is the Lopan River. The Lopan River is one of the small rivers with a length of 93 km and 810 km³ drainage basin inside Kharkiv region.

The balanced model was developed to establish mathematically a connection between existing qualitative data of surface water and both qualitative and quantitative data of wastewaters being treated at the municipal wastewater treatment plant. The model was previously presented at Kalmar ECO-TECH'05, Sweden. [5]



Data was collected in an average of once a month for the period from year 1999 to 2003. Moreover, qualitative indicators were collected from the Lopan river in two distinct points: Control Point 1 (CP1) situated upstream of the Kharkiv city about 1 km; and Control Point 2 (CP2), 350 m downstream from the municipal wastewater discharge point. The regression parameters were determined for suspended solids, nitrites, ammonium, mineralization and chlorides. By using the proposed model it is possible to estimate the values for different qualitative parameters of water at CP2 that was set 350 m downstream of the discharge point of the municipal wastewater treatment plant. The model presented clear variations of water quality and a linear correlation with the amount of water demanded over the public system supply, in which with higher amounts of water use posed the worst scenario (Table 1), reasonably except for the suspended solids once when higher amounts of water are used and discharged, the dilution factor increase, and then lower values of suspended solids will be found..

Table 1. Pollutants concentration (mg/l) estimated at CP2 [5].

Level of public water use , l/person * day	350	250	150
Suspended solids	11	12	13,1
Ammonium	1,309	1,082	0,828
Nitrites	0,272	0,204	0,149
Mineralization	820	800	725
Chlorides	79	70	64

As already presented and according to the proposed model the improvement of the surface water quality throughout the Ukrainian Country may be dependent on the level of the water demand posed by the population and their basic necessities. As mentioned above, the 70% of public water used in Ukraine is for toilet flush [6]. Therefore, it is important to emphasize that strong efforts should be focused to develop and implement creative options to overcome the current situation, otherwise the existing sanitation model based on “flush and discharge” systems will continue to be the main cause for water shortage, depleting quantitatively and qualitatively water resources, consequently bringing major problems to public health and environment. Furthermore, it may bring considerable constraints for the economical sector once the total cost and investments for remediation of the environmental pollution and human diseases will be heavy, principally in urban areas if they continue to discharge under-treated wastewater into open environment.

In Ukraine, flush toilets may be divided into two main categories: public and private toilets. Both systems will be addressed in this present paper. Daily approximately 100,000 people use the public toilets implemented throughout the city. This number could be doubled reaching up to 200,000 people using it on special occasions such as specific celebration days [8].

Public toilets can be divided on two main types:

1. Mobile toilets, that are used specially during holidays and in the spring-summer period, and,
2. Stationary toilets that are used continuously along the whole year.

There are 32 stationary public toilets in Kharkiv city, most of them built in the 50th decade of the last century. Recently, they were under some restoration and



reconstruction process, however without the implementation of any up-dated or environmentally friend technology. Reasonably, these facilities have implemented heat systems; as well as water and electricity. However these resources have not been used in an efficient way as it can be seen in Table 2. Furthermore an inappropriate sanitary condition leads to the insect presence in the summer time and bad smell all year around.

Table 2. Resources use in public toilets in Kharkiv city [8].

No	Resource	Annual use
1	Electricity	245760 KWt
2	Water	14016 m ³
3	Heat	24 Gkal
4	Chlorine	11,2 tons

Concerning private toilets, they can be mainly divided on two groups. The first group is related to the toilets in multi-stored buildings and in cottage type buildings that are connected to the municipal wastewater system. 95% of multi-stores buildings (flat type) are connected to the wastewater systems as well as 15% of the cottage type buildings of the city are [9]. The second group can be considered as the existing toilets within existing buildings without connection to the municipal wastewater system.

About 89,441 cottage type buildings are not provided with both drinking water facilities and sewerage systems, thus they are using simply pit latrines [9]. Regarding this type of sanitation that exists in Ukraine, they can be considered as primitive systems, and when not well planned or managed they can bring serious negative outcomes for the environment and the human health, principally in areas where a high groundwater level may exist and not well educated people are using it [8]. Additionally, the soil can be disturbed and contaminated as well, making it improper to be used for agricultural purposes. The system works basically with a weak built structure such as wood, with a dug hole on the ground that is filled continuously until certain depth. When it is filled the toilet either is covered with some organic material and then abandoned with the construction of another one or some manual or mechanical tools can be used to empty it to continue its usage. As presented already, such toilets are neither environmental nor ecological and sanitary friendly [8]. Specifically translating it into the Ukrainian situation, the city of Kharkiv has been suffering of common floating coming from leakages of inefficient implemented pipe systems increasing significantly the water table. Therefore, both for current scenario and for a long-term perspective this sanitation model should be banned.

Translating the problem into quantitative data and taking into account that 500 liters of urine and 50 kg of faeces are generated per person every year [8], it means that in Ukraine 196,770 persons that have been using pit latrines are discharging annually 98,385 m³ of urine and 9838.5 tons of faeces into the environment without treatment each year. The pollutants of extreme interest contained in human excreta are presented in Table 3 and Table 4 taking into account their respective loads calculated for the Ukrainian situation [9].

Table 3. Physical and Chemical Pollutant load from Pit Latrines according to values presented [9].

No	Component	Pollutant load from Pit Latrines (tons per
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		year)
1	Suspended solids	12,7
2	Nitrogen of Ammonium salts	1,57
3	Phosphates	0,64
4	Chlorides	1,77

Table 4. Microbiological Pollutant Load from Ukrainian Pit Latrines [10].

Microorganism	Average Number of Organisms per Gram of faeces*	Pollutant Load in Ukraine per year (Number of Organisms)
<i>Enteroviruses</i>	10^6	$\approx 10^{16}$
<i>Salmonella spp</i>	10^6	$\approx 10^{16}$
<i>Vibrio cholerae</i>	10^6	$\approx 10^{16}$
<i>Escherichia coli</i>	10^8	$\approx 10^{18}$
<i>Entamoeba histolytica</i>	10^5	$\approx 10^{15}$

Water minimization technologies to be used in public sectors could provide better sanitation and reduce negative environmental impacts of municipal enterprises once waterless or dry toilets have the potential to reduce water use and divert pollutant loads from the sewage system. However it must be preferably implemented and maintained in a proper way, differently than the scenario that can be seen in Ukraine.

WATER USE MINIMIZATION AND DRY TOILET PERSPECTIVES

For the purpose to carry out a comparative analysis of dry toilets and its implementation in Kharkiv using the environmental, economic and social factors were approached. The pilot social survey was carried out in Kharkiv city in order to assess the social acceptability to change old habits and use dry toilets instead of conventional systems. The social survey was made through questionnaires and interviews along the population. A total of 34 responses were received. As an important outcome it was observed that significant percentage of the interviewed persons (68 %) showed to be ready for involvement in water saving activities. Unfortunately no information about dry toilets or other eco-toilets concerning their economical, environmental and ecological benefits is already spread for the Ukrainian population. Among all of persons that answered the social survey, uniquely 3 % of them have knowledge concerning composting toilets; however 99 % of them never used it. Thus it is important to highlight that before dry toilets are introduced on Ukrainian market, a specific effort should be devoted to consumer education and awareness of eco-toilet systems. Furthermore, focus could be on the way of better implementation as well as operation and maintenance. Dry composting toilets, when well planned and managed, meet necessary health and environmental protection. They can treat and sanitize the human excreta and reduce drastically the amount of water used and discharged in conventional systems as well [11].

There are different types of dry toilets as well as different technical concepts; however, they shall be preferably implemented according to some specific conditions of the region such as climate conditions, social status, prevailing water-borne diseases, legal standards regarding organic material disposal and others. Moreover, it is important to



emphasize that the implementation of dry toilet systems in Kharkiv or wherever it should be, must be based on a detailed and reliable study regarding its feasibility for otherwise it can bring several constraints for the environment as well as for the society instead of bringing benefits [11].

Table 4 shows some indicators and their respective values comparing conventional flush toilets and composting dry toilets. Regarding the conventional flush toilets this data is related to simple systems containing 6 toilet cabins and 2 water taps connected to the public system. It can be highlighted that only direct criteria are elucidated Table 4, not taking into account significant indicators of environmental and sanitary aspects such as reduction of pollutant load into the wastewater treatment plants and water bodies, energy use minimization for transportation and wastewater treatment plants, reduction of seepages in sewage pipes, potential for synthetic fertilizers replacement etc.

Table 4. Comparative criteria of public toilets implementation [8].

Criteria	Indicator	Conventional water flush toilet	Composting dry toilet
Economic	Capital costs, \$	1000-2000	2000-3000
	Operational costs, \$/year	500	700
	Municipal bill, \$/year	112	65
	Rent and taxes, \$/year	70	70
	Charge (profit), \$ /year	1000	1100
Environmental	Water use, m ³ /year	105	15
	Chemical materials use, kg/year	250	14
	Energy use, KWt/year	768	555
Social	N ^o of employees, person	2	3
	N ^o of visitors	5000	5500

Therefore as it can be observed, a detailed criteria analysis may bring important information to provide a reliable assessment of dry toilets implementation to be further used by the decision makers. Additionally, such projects' implementation should also take into account existing risks and its management, including:

1. Financial risks;
2. Technical risks, and;
3. Health risks

Simple risk analysis can be observed in Table 5. It focuses the main concepts to carry out risk analysis addressed for dry toilets. One of possible technical constraints is the large amount of human excreta that is discharged into the toilet. Consequently, a predictive measure should be developed.

**Table 5.** Simple risk analysis of public dry toilet implementation.

Aspect	Risk	Risk Management	Preliminary qualitative assessment
Cost of installation and operation	Cost is higher than estimated	Detailed costs analysis at design stage; future agreement with suppliers, costs confirmation	Acceptable level
Market reaction	Unfavorable reaction, not or few visitors	Survey of prospective customers; PR technologies use for eco-living introduction; optimal price	Acceptable level
Complaints	Visitors complains	Providing owner with information to convey visitors	Low level
Occupation	Disease transmissions to other occupiers	Ventilation; cleaning in time; insecticide spray; automatic door, proper operation and maintenance	Low level

CONCLUSION AND RECOMMENDATIONS

Dry toilets might be a future sustainable sanitation technology, helping to overcome current water scarcity and problems of pollution as well as human diseases. Developing countries such as Ukraine have been facing with several environmental constraints meaning that to change it, the implementation of environmentally friend technologies, such as dry sanitation systems shall be taken into account. However there is a lack of research and information about this kind of systems principally regarding comparative analysis. Moreover, a detailed market analysis should be carried out in order to evaluate and achieve reliable answers regarding the real practical aspects and its advantages of dry toilets usage in public toilet services and in households for replacement of conventional models. Environmental aspects such as water use minimization might also be addressed and shown through model analysis.

Preliminary social survey results have shown that, mostly, the Ukrainian society is not well concerned in current environmental problems as well as its needed solutions. Therefore, efforts should be done to develop educational and instructive social programmes for a better understand of existing problems, solve them as well as the magnitude of natural resources conservation. The enthusiasm of citizens can be transferred into concrete actions towards economical growth, as well as ecological and environmental sustainability.

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