Stockholm Junior Water Prize

Hungarian Competition, 2016

What Can We Gain by Using Greywater?

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SHORT ABSTRACT

Using greywater in Hungarian public buildings is not legally regulated and greywater systems work in just a few institutions. Rainwater is widely used in villages – and is also in public buildings where working greywater systems can be found. We use calculations to justify that a lot of money and water could be saved in schools if rainwater were used for toilet flushing. We shared the results with our schoolmates in a summarizing short film which highlighted how water is wasted in our school and which are the saving opportunities for the situation.

STATEMENT OF WORK

We started our study by collecting data about greywater and buildings which use greywater. We inspected the water sanitation facilities in a mall, where the head of the technical department explained the technical details and costs of the system.

We conducted surveys to obtain data about in-school water consumption. These data were then compared to the consumption of the house belonging to one of our teachers, in order to point out water-saving solutions.

Our short film was directed and produced with the help of our classmates. Foreign language texts were edited by our teachers.

INTRODUCTION OF THE STUDENTS

Ákos Iván Szűcs (16)

I have been a student of the Kada Elek Secondary School since 2013. I enjoy history and economy, but I am also interested in biology and chemistry. In the future, I would like to study criminal law. I want to be a lawyer, but I will always deal with the environment.

Dávid Kovács (17)

My main interests lie in the fields of mathematics and economics, but I am also fascinated by some aspects of chemistry. In the future, I would like to study economics, but I would still be interested in chemistry too.

EXTENDED SUMMARY

In Hungary, the efficient use of greywater is in its infancy stage and there are few active greywater systems in public buildings. These buildings mostly use rainwater, as people in villages also do. The operation of a greywater system is highly expensive and it is not profitable at the time, because of its continuous (and expensive) maintenance. Moreover, because of the uneven distribution of rainfall in Hungary, water saving is unpredictable. That is probably the reason why greywater systems are not wide spread in the construction industry.

We made calculations about the distribution of using water in our school, and we concluded that water is used in a highly wasteful manner and the outdated school equipment does not help improve environmental awareness.

The concept of greywater, its usability, as well as the technical solutions are unknown to young people. We confronted our schoolmates with this fact in a self-made film. Furthermore, our study demonstrates that it is worth using rainwater for toilet flushing in our school, as a lot of money can be saved this way.

Using greywater is not popular in Hungary, but through this work we would like to emphasize the importance of using modern water technology equipment in order to save both water and money. The most important issues from this point of view are the change in attitude and the encouragement of future generations to change water-wasting conditions. In our opinion, the greatest saving can be reached by stopping wasteful usage. In order to accomplish this, we need to draw the attention of our schoolmates to the fact that this is a real problem which can be solved.

INTRODUCTION

THE IMPORTANCE AND OCCURRENCE OF WATER

Water is an essential compound of life, which, according to our current knowledge, exists in liquid consistency only on the Earth in the solar system. Only 3% of the terrestrial water resources is freshwater, only 1% of which can be used for rural, industrial aims, and directly for human consumption.

Because the population of the Earth is growing fast, the demand for water is raising exponentially. One of the biggest problems is wasteful, reckless water usage and overconsumption, which is worsened by the following factors:

- The unequal geographical distribution of water resources
- Regional water shortage due to global warming
- The growing number of megacities, where the population density is so high that water demand issues are solved with difficulty.

Today, 20% of the Earth's population do not have access to clean drinking water, and it is expected that this number will rise. This results in the necessity of saving drinking water, decreasing unnecessary overconsumption, and using direct water-saving opportunities.

GREYWATER

What is greywater and how is it used in a modern public building?

As a result of using water, it gets dirty, especially when discussing industrial and communal sewage. Greywater is the less contaminated form of communal sewage. This includes bathwater, wash water, dishwater, and rainwater. It is significant because of two main reasons: this is the kind of sewage that is mostly generated in every household; and it can be cleaned with relatively small energy input to make it reusable in certain conditions (e. g. toilet flushing, car cleaning, watering, etc.)

AIMS

Our research is constructed on three main points. Firstly, we gather as much information as possible about the buildings in Hungary with active greywater systems and present them thoroughly. Furthermore, we test the economy of greywater usage in our school and in households. We test if an active system can be installed in a high school or at home, particularly because there is no example of such a system extant in Hungary.

Secondly, we aim to explore utilization problems and obstacles.

Thirdly, we test the awareness of our schoolmates in the given topic and we promote the topic through an informative video which shows the importance of environmental consciousness among high school students.

Our aims are:

- To show how much drinking water and money can be saved by using greywater in schools and households.
- To present the problems which could prevent water saving.
- To raise the awareness of our schoolmates on wasting water with the help of a short film.

PRACTICAL EXAMPLES OF USING GREYWATER

TASKS TO SOLVE IN GREYWATER UTILIZATION

After we reviewed the existing Hungarian examples, we realized what kind of practical tasks need to be solved during greywater utilization. The followings list includes some of the problems to be solved in the utilization of greywater:

- Collection
- Filtration, cleaning, disinfectioning
- Storage
- Transportation
- Consumption

ACTIVE GREYWATER SYSTEMS

Greywater usage is not wide spread in Hungary. We could only find three buildings with active greywater systems:

- The Rector's Office at the University in Szeged (Szeged, Dugonics square 13.)
- The Hegyvidék Supermarket (Budapest, Apor Vilmos square 11.)
- Váci Greens Business Center (Budapest, Bence street)

On the 21st of March 2016, we visited the Hegyvidék Supermarket, where we examined the engineering and water supply system. We received here exact data on water usage, functional costs, and the savings resulted from using the system. The number of lavatories of the supermarket is about the same as in our school, but there are also some other water consumers in the building (e. g. restaurant, coffee shop). Because of this, we only examined rainwater usage and greywater resulted from handwashing.

Greywater is gathered in the Hegyvidék Supermarket in two 10 m^3 containers. The first container collects the water from the green roof and from the ground, and it is used for watering. The system works smoothly.

Figure 1 – The roof of the supermarket (Rainwater collection)

Figure 2 – Greywater-collecting containers, pipe system, filtration device

The second container collects greywater resulted from handwashing. This water contains floating contaminants, epithelial, liquid detergent, and probably other organic contaminations (e.g. blood, bacteria). Because of this, handwashing water is often considered as blackwater. Reusing greywater from the washbasin is not economical with the current technical system, but after the right chemical treatment and settling, 93% of the collected water could be used for toilet flushing, so the supermarket could save a lot of drinking water. This is why the economical usage of the system and water saving methods need more investment and effort. The wastewater treatment system cost between three and five million HUF when the supermarket was built. The toilet containers flush with two kinds of water flows and the handwashing taps have modern sensors, so they dose little quantities of water (200 cm^3) for handwashing. The equipment for water usage was built with care, by paying attention to economical aspects, while also minding aesthetical and hygienic aspects.

Figure 3 – Washbasin with sensor, in the toilet of the supermarket

The operating costs (cleaning, chemicals, removal of sedimented waste, changing and maintaining filters) are 30 000 HUF/month. Furthermore, the system needs the presence of professionals. However, the dangerous waste containing chemicals from the settlings also pollutes the environment.

A STUDY OF SCHOOL WATER CONSUMPTION

During our visit to the supermarket, we noticed several problems such as water purification and technical capabilities. This is the reason why we decided to only analyze the benefits of rainwater usage possibilities in our study. This way, we are able to make accurate comparative calculations.

WORKING METHOD

- We gathered the water consumptions bills from the 2014/2015 school year.
- We gathered information on our schoolmates' water consumption with the help of a questionnaire (Appendix 1.) and measured the other water use forms (cleaning, school buffet, teacher's coffee, toilet in the teacher's room, showers in the dressing room).
- According to the data collected, we created a daily water consumption breakdown for our school.
- We examined the condition of the water supply system in our school.
- We calculated the amount of the rainwater collectable on the school's roof.
- We calculated the theoretically-savable water flow and based on the data in Table 1, we defined the possible savings in HUF.

WATER CONSUMPTION AND FINANCIAL DATA (2014/2015 SCHOOL YEAR) – 10 MONTHS

Our school water consumption was 1 100 m^3 in the period under review, which means 5.69 m^3 water was consumed daily. This table contains the expenses related to the quantity of water consumed (public pricing):

Table 1 – Public water fee pricing

Water consumed 268 HUF/m^3	Drinking water basic fee* 134 HUF/month	Wastewater treatment and drainage basic fee* 109 HUF/month	Proportional amount of water lost in sewage fees 244 HUF/m^3	Charged water pollution cost 6 HUF/m^3	Nett fee (HUF)	General Sales tax (%)	Gross fee (HUF)
294 800	1 340	1 090	268 400	6 600	572 230	27	726 732

**The basic fee is paid regardless of consumption.*

We used a survey to receive information about the toilet and lavatory usage customs and frequency. There are on average 600-620 people in the building daily. Every day students used and average 6.5 litres for toilet flushing and 1.2 litres for handwashing. These data were estimated as the average of our empirical measurements. The amount of water needed for a single shower was determined by measurements. In order to gain the data on water consumption in the buffet, we asked the renter. The table and the chart below show the daily water consumption from handwashing (5.69 m^3) and its distribution.

Table 2 – Daily water consumption data in our institution.

	Using the toilet	Handwashing	Cleaning the building	Shower	Kitchen	Buffet	Drinking water	All
m^3	4.16	0.8	0.38	0.1	0.05	0.1	0.1	5.69

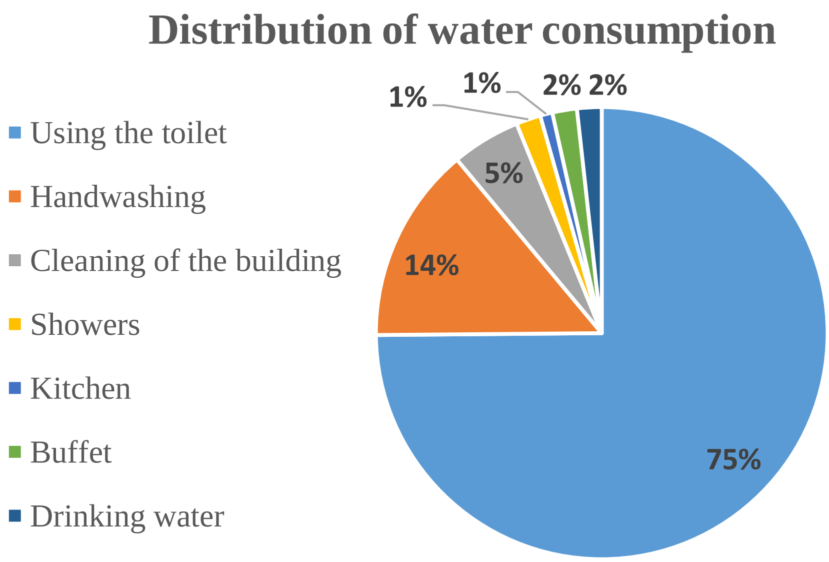


Figure 4 – Distribution of water consumption in our school, based on estimated data.

The third table contains the annual distribution of water consumption data.

Table 3 – The distribution of the annual water consumption

Location of water consumption	Quality of consumed water	Amount of used water (m^3)	Quality of effluent water	Usefulness	Available water quantity (m^3)
Toilet flushing	Drinking water	823.57	Blackwater	Non-recoverable	0
Wash basins	Drinking water	155.1	Greywater	Recoverable with right equipment	(cca. 7% loss) 144.2
Cleaning	Drinking water	53.9	Blackwater	Non-recoverable	0
Showers in the dressing rooms	Drinking water	19.25	Greywater	Recoverable with right equipment	(7% loss) 17.9
Teacher's small kitchen		9.68	Blackwater	Non-recoverable	0
School buffet	Drinking water	19.25	Blackwater	Non-recoverable	0
Drinking water consumption	Drinking water	19.25	-	-	-
All	Drinking water	1100 m^3			162.1 m^3

According to Table 3, 162.1 m^3 of greywater suitable for toilet flushing was not utilized in the school year of 2014/2015, because of the present conditions of our school (there is no greywater system built). As a result, there were no additional costs of chemical treatment and the delivery of the greywater generated.

The water-engineering facilities of our school are quite out of date. Toilet flushing is hand-guided so it is technically unreliable (it can get stuck, does not seal perfectly, it can flow). In the case of washbasins, it is not possible to make water consumption more economical with angle valves and perles.

Figure 4 – Washbasin in the toilet of the school

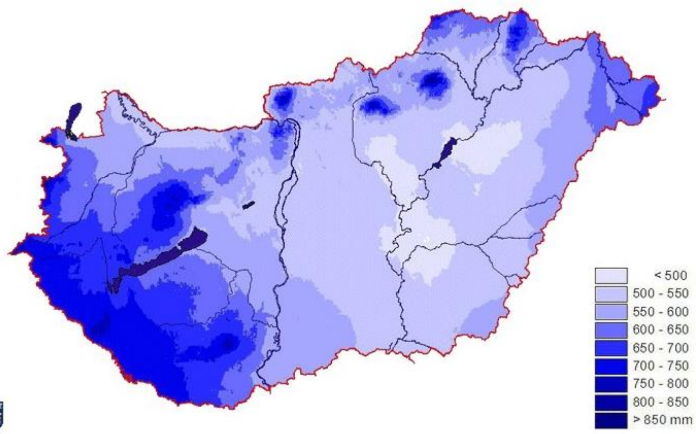
LEGAL REGULATION OF GREYWATER USING

While conducting our research, we had difficulties in finding legal regulation on the usability of greywater and the rainwater. According to decree No. 253/1997 (XII. 20.) § 56/B: "During the planning, construction and demolition of a building and its parts, it is necessary to aim at the following aspects: … c) the economical use of water, the possibility of using precipitation, subsoil water and greywater, or the use of appliances suitable for an efficient reducing of water use.”

The National Town Planning and Building Requirements also include construction-related and technical regulations about the transportation of rainwater. Therefore, there is no obstacle to use rainwater for toilet flushing in schools.

THE CALCULATION OF THE AMOUNT OF RAINWATER COLLECTABLE ON THE ROOF OF OUR SCHOOL

The amount of precipitation in Kecskemét and the surrounding area is 500-550 mm/year, on average. According to the data provided by the monitoring stations in Kecskemét, a total of 492 mm of rain fell in the school year of 2014/15.



Source: http://www.met.hu/eghajlat/magyarorszag_eghajlata/altalanos_eghajlati_jellemzes/csapadek, Last time accessed: 30.03.2016

Figure 5 – Hungary's rainfall map (2014/2015)

Table 4 – Meteorological Observatory Weather Information of Kecskemét (2014/2015)

Period		Average	Maximum	Minimum	Precipitation (mm)
		Temperature (Cº)			
2014	**January**	2,3	13,4	-14,3	24
	February	4,2	14,7	-10,9	31
	March	9,4	21,6	-2,0	8
	April	12,7	23,1	0,7	36
	May	15,5	28,4	2,4	97
	June	19,8	34,5	7,6	25
	July	22,1	33,5	9,6	120
	August	20,2	31,9	7,9	95
	September	17,2	29,9	3,0	101
	October	12,4	26,5	-2,4	104
	November	7,2	21,8	-1,6	22
	December	3,3	13,2	-12,4	41
	January-December	12,2	34,5	-14,3	703
2015	**January**	2,2	12,0	-12,8	67
	February	2,0	13,2	-10,5	32
	March	6,9	18,8	-5,7	24
	April	11,3	27,1	-2,3	14
	May	16,6	30,0	4,5	64
	June	20,4	33,3	8,1	23
	July	23,8	37,7	9,5	49
	August	23,3	37,1	8,5	55
	September	17,9	34,8	4,3	61

Source: https://www.ksh.hu/docs/hun/xstadat/xstadat_evkozi/e_met003.html

The amount of rainwater (m^3/year)=receiving surface (m^2) x annual rainfall (m) x runoff coefficient [formula source*: http://www.pannonmuhely.hu/pdf/autonom.pdf ,Ertsey Attila: (The Autonomous house)*]

The amount of the theoretically-collectable rainwater in our school during the school year of 2014/15
$1634\ m^2 \times 0.492\ m \times 0.75 = 602{,}94\ m^3$/year ~ **600 m^3/year**

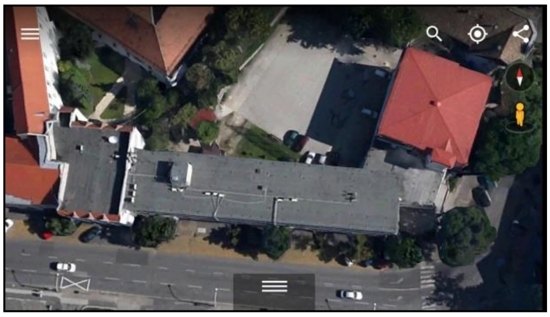


Figure 6 – The building of the Elek Kada Economic Vocational School in Kecskemét

Therefore, the amount of the theoretically-collectable rainwater during the last academic year was 600 m^3. All of it could have been used for flushing the toilets, and it would have covered the water needed for toilets.

If there were systems for collecting rainwater and greywater in our school, we could save 394 716 HUF with the rainwater system and 106 573 HUF with the use of greywater, according to Table 1.

However, according to the information gained in the supermarket, the treatment of greywater is very costly and it requires a special water network.

EXPECTED TECHNICAL PROBLEMS AND OTHER PROBLEMS IN OUR SCHOOL

- Collecting, filtering and transporting rainwater is a huge investment, and there are no funds for this.
- In case of a problem, quick intervention is not possible, because there is no constant maintenance present.
- The solid wastes in greywater (for example chalk) could cause serious damage. Spare parts are required for the system.
- There are short and long breaks in our school. Because of this, it is impossible to maintain constant water circulation. During school breaks the collected rainwater and greywater is not utilized and it accumulates.
- Rainfall distribution is uneven.

CONCLUSION

Water consumption in our school is highly wasteful because students are not environmentally-conscious and because of the obsolete technical conditions. The annual rainfall could cover the amount of water needed for toilet flushing, but because of the uneven distribution of rainfall, the necessary quantity of water is not provided. The reconstruction and restoration of the school waterwork system would require extensive investments, and the return of the invested money is unpredictable. Based on the recent data, the cost of water from the system of rotation of handwashing sinks is disproportionately high. By using rainwater, the situation would improve. Laws do not regulate the usage of rainwater in public institutions -- this is why it would be beneficial to explore the theoretical and technical possibilities for the reconstruction of the water network in the school.

THE UTILIZATION OF GREYWATER PRODUCED BY HOUSEHOLDS

WORKING METHODS

- Collecting the water bills of a family and determining the family's water consumption and its cost during the past year (2015).
- Calculating the distribution of water consumption based on statistical data.
- Calculating the amount of water which could be collected on the roof of the house.
- Calculating the amount of water saving in the household, as well as the financial savings (in HUF) based on the water and sewer fees.

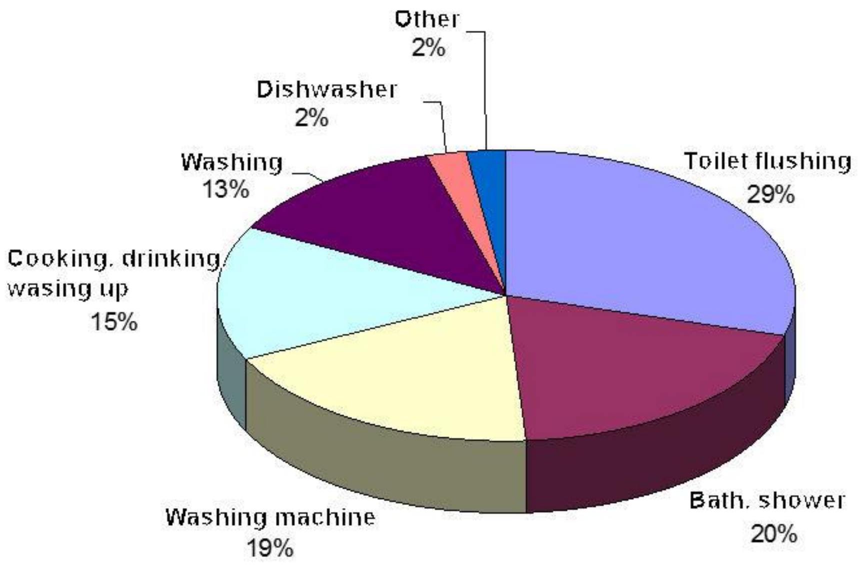
WATER CONSUMPTION AND FINANCIAL DATA

Based on the bills received in 2015, the family used 108 m^3 water/year. Table 5 shows the expenses related to the amount of water consumed.

Table 5 – Pricing of the consumed water.

Water consumed 241 Ft/m^3	Drinking water basic fee* 17 HUF/month	Wastewater treatment and drainage basic fee 98 HUF/month*	Proportional amount of water lost in sewage fees 219 HUF/m^3	Charged water pollution cost 5 HUF/m^3	Nett fee (HUF)	General sales tax (%)	Gross fee (HUF)
26 028	204	1176	23 652	540	51 600	27	65 532

**The basic fee payable regardless of consumption form.*



Source: www.vkkt.bme.hu/feltoltesek/2010/10/kmh_vízigények.ppt

Figure 7 – Distribution of household water consumption of Hungary

Table 6 shows the distribution of annual water consumption based on statistic data.

Table 6 – Distribution of annual water consumption.

Location of water consumption	Quality of consumed water	Amount of used water (m^3)	Quality of effluent water	Usefulness	Available water quantity (m^3)
Toilet flushing (29%)	Drinking water	31.3	Blackwater	Non-recoverable	0
Bath, shower (20%)	Drinking water	21.6	Greywater	Recoverable with right equipment	about 20
Washing machine (19%)	Drinking water	20.5	Blackwater	Recoverable with right equipment	about 19
Cooking, drinking, washing (15%)	Drinking water	16.2	Greywater	-	-
Washing by hand (13%)		14.08	Blackwater	Recoverable with right equipment	about 13
Dishwasher (2%)	Drinking water	2.16	Blackwater	-	-
Other (2%)	Drinking water	2.16	-	-	-
All	Drinking water	108 m^3			about 52 m^3

Based on Table 6, in a detached house, almost half of the used water could be reused for toilet flushing. This is more than the necessary amount. It would be promising to use rainwater for toilet flushing and washing. The construction of this technology is easier and it could be done by the owners themselves, without professional intervention. Based on the table, 52 m^3 drinking water could be saved, which costs about 30 708 HUF.

THE CALCULATION OF THE AMOUNT OF COLLECTABLE RAINWATER ON THE ROOFS OF HOUSES (2015)

We used the previous formula (please see it again in, Fig. 8 below), because the house examined is in Kecskemét.

Figure 8 – Our teacher's house is situated near Kecskemét

The amount of the rainwater in 2015 (m^3/year)=130 (m^2) x 0.532 (m) x 0.75 = **51.87 (m^3/year)**

EXPECTED TECHNICAL PROBLEMS AND OTHER PROBLEMS IN THE HOUSE

- Because of the organic contaminants from washing and bathing, greywater can be stored for only a short time.
- Building an odour-free, aesthetic and hygienic toilet demands expensive equipment, serious investments, chemical treatment, and maintenance.
- Because of the uneven distribution of precipitation, a large storage capacity must exist in order to protect the continuous toilet flushing and washing.

CONCLUSION:

In the case of the house, using rainwater is easy and can be solved with individual tools. Many families collect rainwater in containers daily, and use it to water plants. The cost of this system is small and the practice is popular. The family house we examined also used this practice.

If we reuse greywater inside the house, the saved water can be significant, but it is highly expensive to build the needed hygienic system. Furthermore, operating the system involves additional costs. Therefore, it is unlikely that the family would undertake such a large expenditure for such little financial savings.

REMARKS BASED ON OUR STUDY

Today, the conscious use of water and the protection of drinking water is becoming increasingly important. This is a constant topic in education and the media, and people are encouraged to make practical implementations in their lifestyle (irrigation with rainwater, reusing greywater, etc.). However, this is insufficient if schools have out-of-date systems and undemanding water usage equipment. The difference is obvious between the obsolete system of our school and an institution with modern equipment.

Only those who have seen economical systems are able to notice their own water wastage. This is why we believe that institutions and schools should build modern, water-saving and reliable systems, even if this requires additional costs.

We believe that the greatest savings can be achieved if we stop wasting water. In order to accomplish this, we should raise awareness on this problem in order to encourage people to be open for water-saving solutions. Furthermore, we recommend that schools modernized their water networks and the out-dated equipment.

The short film that was discussed in this study (and was produced by us) can be seen at the following link:

https://youtu.be/B8mdRJ8iyZY
or
bit.ly/GreyWaterHun

APPENDIX 1 – QUESTIONNAIRE ON USING WATER

Dear fellow students,

We would like to ask for your help for our project to be submitted to the Stockholm Junior Water Prize Competition. We will inquire how many times you use the washbasin tap, the toilet, the dressing room shower, etc. in the school.

Please mark your option with an X!

1. How many times/day do you use the school washbasin taps for handwashing?

Not at all	Once a day	Twice a day	Three times a day	4-6 times a day

2. How many times/day do you use the school's toilets/pissoirs?

Not at all	Once a day	Twice a day	Three times a day	4-6 times a day

3. How many times/week do you use the showers after the Physical Education class?

Not at all	Once a week	Twice a week	Three times a week	Four times a week	Five times a week

4. Do you use tap water to fill your water bottle? If yes, how many liters/day?

I do not fill my bottle.	I fill my bottle daily, when it runs out.
	I use about …………….liters on a school day

Thank you for your answers! ☺

(Ákos Iván Szűcs 10.d, Dávid Kovács 10.d)

PARAMETERS

School staff figures:

Number of students	628
Number of teachers	52 (Temporary presence)
Administrators, cleaners, maintenance, reception	13 people
Total of people	693 persons
Average absence (12%)	83 persons
Always present	610 persons

Questionnaire and frequency figures:

	Amount of water needed for hand washing on one occasion	Amount of water needed for one shower:
Number of measurements	50 measured occasions	7 measured occasions
Average	0.37 litre/occasion	7 minute/occasion 40.1 litres/occasion
Deviation	0.5 litre	3.14 minutes
Quantity of running water per minute		5.7 litres/minute

The questionnaire was filled in by 585 students.

Hand washing	Not at all	Once a day	Twice a day	Three times a day	4-6 times a day	Average: 3.46 occasions/day
Students	0	49	104	196	236	

Showers	Not at all	Once a week	Twice a week	Three times a week	Four times a week	Five times a week	Average 12 occasions/week
Students	578	3	3	1	0	0	

	Hand washing	Showers
Amount of water used per day	0.78 m^3	-
Amount of water used per week	3.89 m^3	0.48 m^3
Amount of water used in a school year	155.1 m^3	19.25 m^3

SOURCES

[1] http://tudasbazis.sulinet.hu/hu/termeszettudomanyok/foldrajz/termeszetfoldrajz/a-foldi-vizkeszlet-eredete-megoszlasa-korforgasa/a-fold-vizkeszletenek-jellemzoi
(The features of Earth's water resources, their origin, distribution, and circulation)

[2] http://eng.unideb.hu/dmk/docs/20142/haja.pdf
(The utilisation of greywater in the house with the application of heat pump systems)

[3] http://www.maviz.org/meddig_eleg_a_fold_vizkeszlete
(How long will the world's water resources last?) (Article)

[4] http://www.bacsviz.hu/telepulesi-adatok/?telepules=kecskemet
(Municipal data)

[5] www.vkkt.bme.hu/feltoltesek/2010/10/kmh_vízigények.ppt
(Water needs) (Diagram)

[6] http://www.pannonmuhely.hu/pdf/autonom.pdf, Ertsey Attila: Az Autonóm Ház
(The autonomous/self-maintaining house)

[7] https://www.ksh.hu/docs/hun/xstadat/xstadat_evkozi/e_met003.html
(Meteorological data from Kecskemét's observation station)

ASSISTANTS

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