

CITY CHALLENGE FINAL REPORT

City Challenge Title: *Waste disposal: problems and solutions*

School: National Highschool „Gheorghe Șincai”, Bucharest

Teachers: Rusu Contesina Maria- *Physics*

Tomescu Liliana- *Biology*

Stancu Iulian – *Physics*

Members of the science team (students) :

Deliu Georgiana- captain, researcher and editor

Buruleanu Vlad - researcher's team captain

Iliescu Miruna- researcher

Barbaresso Cristian – researcher

Dincă Ana – researcher

Cocuz Vlad – researcher

Science Reporters: (students)

Zybaczynski Karina- editor, reporter's team captain

Botorogeanu Valentina -editor

Gheorghiu Eva- researcher, editor

Cană Alexandra - researcher, editor

Occasional collaborators (students): Chiper Miruna- English editor, Hurtupan Ana- researcher,
Oprescu Vlad - researcher.

Identifying the Challenge:

According to Eurostat statistics[1], in 2018 Romania had one of the lowest amounts of waste per person in the EU, 272kg per capita, but it also had one of the lowest waste recycling rates, with only about 14% of waste produced being recycled. The rate of separate waste collection is even lower (around 5%, for 2019[2]). In May 2020, Romania entered an EU infringement procedure on community rights and landfill/recycling of waste. Therefore, there is an urgent need for solutions in terms of selective waste disposal and Bucharest, the country's capital, is no exception.

Around 75% of the EU population has chosen to live in urban areas[3]. The impact of urbanisation extends beyond city limits. Europeans have adopted urban lifestyles and make use of urban amenities such as cultural, educational or medical services. Although cities are the engines of Europe's economy and the generators of Europe's prosperity, they depend heavily on the resources of outside regions to meet demands for energy, water, food and to manage waste and polluting emissions. Cities are also the biggest producers of waste, and the need for recycling and selective processing is greatest here.

Today, the problem of waste management is becoming increasingly acute, both because of the growth in the quantity of waste and its increasing diversity, as well as its growing negative impact on the environment. The production of increasing quantities of waste, the variety of pollutants, both organic and inorganic, makes the process of aerobic or anaerobic degradation by micro-organisms difficult, leading to pollution of soil as well as air and water. Ecosystems in the vicinity of landfills are severely affected and imbalances in food chains can occur.

According to the National Agency for Environmental Protection [4] , municipal waste is defined as all waste generated in urban and rural areas from households, institutions, commercial establishments, economic agents (household and similar waste), street waste collected from public spaces, streets, parks, green spaces, construction waste - demolitions and sludge from urban wastewater treatment. In the structure of municipal waste in Romania, household waste (75 - 80%) has the largest share, followed by street waste (10 - 12%), municipal sewage sludge (7 - 9%) and other waste such as construction and demolition waste (7 - 9%), excavation waste (3 - 4%), etc. More than 90% of this waste is disposed of by landfilling. Municipal waste management involves the collection, transport, recovery and disposal of municipal waste, including monitoring of landfills after closure.

From the information presented, it is clear there is a need for careful management and monitoring of waste collection methods, but also a need to find practical solutions to the problem of recycling municipal waste.

In preparing the topic and the research approach, we also mention that the students' observations on the influence of the environment on the quality of their personal life were the starting point of our research in the PULCHRA project. Through this year's project we are experimenting with new ways to increase the efficiency of waste collection, but we also want to see if the traditional way of separate waste collection works in our school.

Our research is based on the following hypotheses:

I1 -the use of small smart devices placed in the bin will reduce the time needed for waste collection;

I2 - students are aware of the importance of selective waste collection;

I3 - pupils use and respect the selective waste collection system.

We expect that the data collected by our students, using the methods of investigation and the devices built by them, will confirm these hypotheses. To test the hypotheses several tools (Arduino devices, sociological questionnaire) were created and measurements of the amount and type of waste in the dedicated bins in the school premises were made.

In the Table 1, below, there is a more detailed presentation of the activities.

Table 1. Activities for identifying the challenge.

Activity	Description	Resources needed	Location
Online Lectures -1	Project presentation -cca 1 hour	Computers and a stable source of Wi-fi/internet Students, teachers, School platform- Google Meets@cnghsincai.ro	Online
Online Lectures -2	The students's roles -cca 1 hour	Computers and a stable source of Wi-fi/internet Students and teachers School platform- Google Meet@cnghsincai.ro	Online
Online Lectures -3	Key elements of scientific research -cca 1 hour	Computers and a stable source of Wi-fi/internet Teachers, PULCHRA school coordinator (CNPEE). School platform- Google Meet@cnghsincai.ro	Online
Online events- 1	PULCHRA event: "Remote sensing for education" -cca 1h	Computers and a stable source of Wi-fi/internet Teachers, students	Online

Online events - 2	<p>PULCHRA workshop: "Cities and Climate Change: new challenges for education at the school level"</p> <p>-cca 1h 1/2</p>	<p>Computers and a stable source of Wi-fi/internet</p> <p>Students, teachers</p>	Online
Online search	<p>Search for information on platforms indicated by the teacher about: waste disposal, waste management, waste selective collection, Arduino smart devices.</p>	<p>-Keywords: waste disposal, waste management, waste selective collection, Arduino smart devices.</p> <p>-Computer and a stable source of WI-FI.</p>	Online

Exploring the challenge

Creating smart devices for measuring waste amounts

The technical team, led by Vlad Buruleanu, first made a prototype of the device and tried mounting it in one of the plastic recycling bins and the school. The idea behind the construction of the device was to make waste collection more efficient by mounting a sensor to warn of how full the bin is with waste.

The first problem encountered was that the school's internet network had insufficient signal for data transmission. This is due to the way the building is constructed, as it is an old building with thick walls, which makes the wi-fi transmission heavily screened.

Another problem was the rapid consumption of the sensor batteries' energy, which makes it impossible to transmit the signal over a longer period of time. The device's batteries ran for about 24 hours until fully discharged and did not provide for monitoring the degree of filling over a longer period of time.

These problems were partially remedied by the students of the technical team and allowed the collection of data on the loading of the plastic container over three consecutive days. ***Unfortunately, however, this period was too short to rigorously test II.***

"Say NO to plastic" campaign and online survey

Another activity carried out as part of the project was the "Say NO to plastic" campaign at school level. This campaign aimed to raise awareness of the fact that a large part of waste is plastic and to identify solutions for its collection and recycling. The campaign started with an online questionnaire which was completed by 28 of the school's students. This questionnaire aimed to explore the knowledge, needs and level of personal and family involvement in separate waste collection both at school and at home. The questionnaire contains both open and closed questions, i.e. short answer and multiple choice questions such as "Does your household recycle?" or "How often do you use the bins in the hallways of your high school to recycle plastic?". The questionnaire was distributed in the form of posters containing a QR code that had to be scanned to answer the questions. Access to the questionnaire is also restricted to holders of the institutional email address @cnghsincai.ro. The posters were placed in the school hallway, in plain view, in the path of students.

Measuring waste amounts in dedicated bins



For the selective waste collection in the high school, the students monitored, over five weeks, the amount of plastic collected in the dedicated bins placed on the hallway and the amount of plastic in the bins in the classrooms located on the floor. At the end of each week, the students weighed the plastic in the dedicated bins as well as the other waste in the dedicated plastic bin. The data obtained during the research was collected in a table and discussed within the project team. On the basis of this data, conclusions were formulated regarding selective waste collection, civic responsibility and proposals to raise awareness of the need for selective collection and recycling of municipal waste.

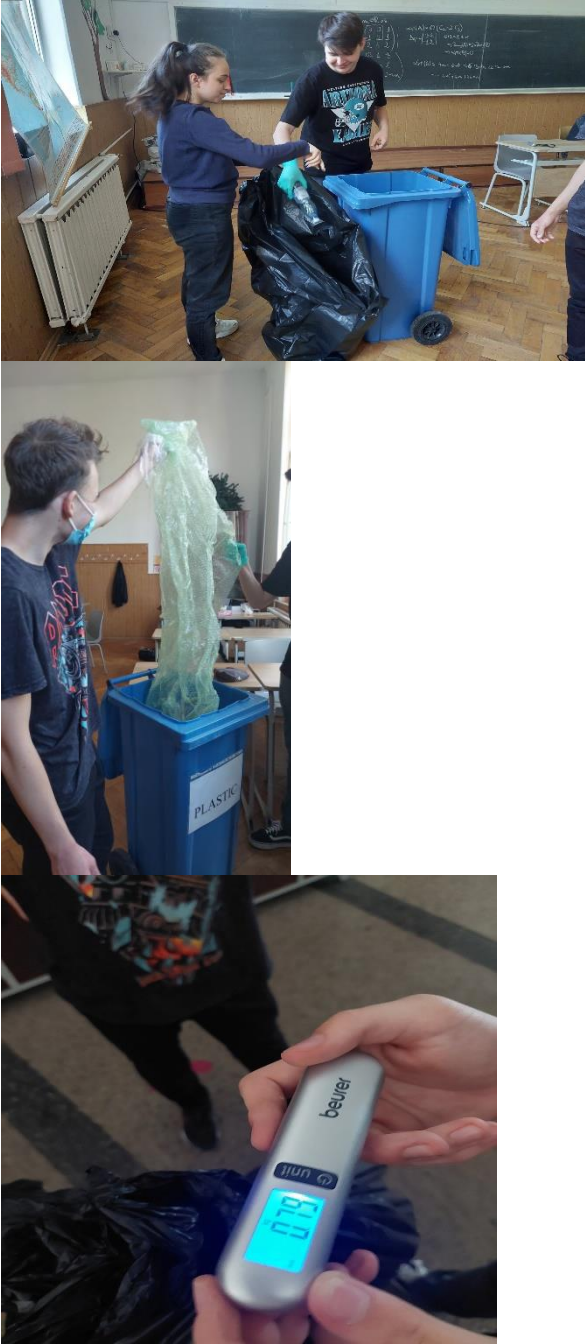
In the Tables 2 and 3, below, you can find a more detailed description of the activities from this stage.




Table 2. Online activities for exploring the challenge.


Activity	Description	Resources needed	Location
Online survey	<p>Applying a questionnaire about the waste recycling. 28 Highschool students responded.</p> 	-Online Questionnaire- Google Forms	Online
Mixed activities – recycling campaign	<p>A flyer was created for promoting plastic recycling and inviting to complete an online questionnaire.</p> 	Paper, internet connection	Online and physical

Table 3. Face-to-face activities for exploring the challenge.

Activity	Description	Resources needed	Location
In-door activity mounting sensors	<div>- assembly and configuration of sensors for recycling bins</div> <div>-cca 2 hours</div> <div></div> <div></div>	Arduino kit, sensors	At school

Activity	Description	Resources needed	Location
In-door activities: measuring waste amounts	<p>Measuring waste amounts from school bins</p> 	Plastic bags, masks, electronic scale	At school
In-door activities: study visit to International Center for Biodynamics	<p>Students learned about the study of various dynamical systems, the importance of maintaining natural equilibrium and became familiar with equipment that facilitates the study of these systems.</p>	Transport means	International Center for Biodynamics (Bucharest)

Activity	Description	Resources needed	Location
	 		
In-door and out-door activities: visit to the Paper Mill and the craft workshops in Comana, Giurgiu county	<p>For students to become familiar with recycling methods used in traditional communities.</p> 	<p>Transport means</p>	<p>Comana, Giurgiu county</p>

Activity	Description	Resources needed	Location
			

Communicate the solution and project results

Results from the online questionnaire

The results of the sociological questionnaire reveal that although the respondents are school students, they are concerned about the quality of their environment. Thus, about 85% of them say that they recycle various objects, mostly plastic, paper, batteries and small household appliances. We believe that this confirms I2 on the importance given to recycling by students.

From the answers received to the question *How would you be more motivated to recycle*, we can deduce that education in the sense of recycling and environmental protection through recycling is deficient among young people. There is also a lack of recycling habits in the family. Recycling is generally seen as something to be rewarded for, not as a duty and obligation to the environment. The reasons why people do not protect the environment enough in their daily lives are, in the respondents' view, mainly carelessness, lack of environmental education, economic interests and excessive urbanisation.

Despite the fact that more than 80% of respondents say they recycle at home, the percentage recycling at school is just over half the previous figure. Only a third say they frequently use bins for selective recycling and almost half say they rarely recycle. Some 18% say they do not recycle at all. The different behaviour may be due to a lack of education and civic responsibility, as well as not being given enough responsibility at home.

Suggestions for measures that could be taken to increase recycling include placing more selective recycling bins inside and outside the school. Students say they would use the bins more often if they were handy. Also, if they were rewarded or saw the usefulness of recycling, possibly products made from recycled materials. They think it would be useful to run campaigns to inform pupils about selective collection for recycling and also civic education campaigns for citizens, aimed at raising awareness of the rights and obligations of each of us and of local authorities and state institutions.

Results from physical measurements

The results of the measurements taken during the last five weeks of school, from 9.05 -10.06.2022, are shown in Table 1. Measurements were made on the last day of the week for the dedicated plastic bins. Note that during the last two weeks, three of the seven classes teaching on the floor went on holiday, being in grade 12. Students from these classes have only been in school sporadically.

Table 1. Measured values of the amount of plastic in dedicated plastic bins

Data	Plastic (kg)	Other waste (kg)	% Plastic	% Other waste
13. 05.2022	0,81	0,14	85,3	14,7
20.05.2022	0,79	0,11	87,8	12,2
27.05.2022	0,75	0,13	85,2	14,8
03.06.2022	0,74	0,15	83,1	16,9
10.06.2022	0,71	0,12	85,5	14,5

Note: From 1-10.06, the students of the 12th grade were on holiday.

The data presented in Table 1 show that the proportion of plastic in plastic bins is high (on average 85%), which partially confirms hypothesis I3 - students use and comply with the separate waste collection system. Differences are also noted between the collected values of plastic over the 5 weeks. This decrease can also be associated with the decrease in the number of pupils present on the landing due to the completion of the courses for grade XII, as well as due to the approach of the holidays.

Research conclusions

The values obtained from the data collection on the amount of plastic, mostly from packaging, lead us to the idea that a more efficient selective waste collection process is important for our school. From the answers to the questionnaire questions, as well as from the values resulting from the determination of the quantity of plastic, it appears that a selective collection system that is more present in the path of the pupils, i.e. more visible, could lead to an increase both in the degree of selective waste collection and in the quantity of waste collected selectively and then recycled.

As for the use of devices to indicate how full a container is for recycling, the idea is useful, welcome, but communication with the source and power supply must be ensured. If implemented on a large scale, this would save time in checking and emptying the contents, reduce fuel consumption, as containers can only be emptied to a convenient degree of fullness.

Proposals and recommendations

The activities carried out by the students of "Gheorghe Șincai" National High School as well as the data collected during the experiments lead to some proposals and recommendations aimed at improving the quality of the selective waste collection and recycling process:

- **Increasing the number of containers for selective waste collection** as well as placing them in visible areas of the school, i.e. in the school yard. This could lead to an increase in the number of waste bins in the school.
- **Involvement of the school in environmental activities and events**, possibly in partnership with environmental associations, NGOs, non-profit associations. This would support students in understanding the importance of daily recycling, changing their habits of collecting household waste and provide them with easy solutions to protect nature. It could also lead to a change in their motivation towards environmentally friendly behaviour.
- **Optimizing the way household waste is collected** - can be done by using devices attached to the container to indicate how full it is. Connecting these devices to a dispatch centre could seriously reduce fuel consumption and the time needed for collection. Collecting machines would only empty containers when they are full.
- In order to increase the selective collection of household waste, it would be useful to have a greater number of collection bins located in the vicinity of the school, which would be of benefit to both the school pupils and the local residents.

These proposals will be sent to all those entitled to take action and support us in continuing our efforts for a cleaner, more human-friendly environment, namely:




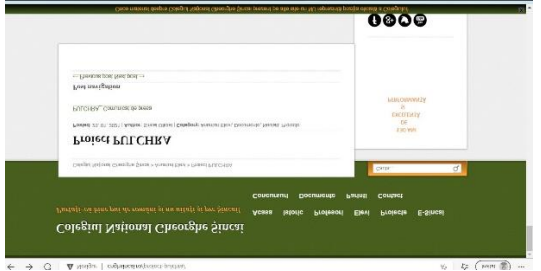

- General Council of the Municipality of Bucharest,
- Bucharest Environmental Protection Agency,
- Sector 4 City Hall,
- The Director of the "Gheorghe Șincai" National College.


In the Tabel 4, below, you can find a more detailed description of the activities from this stage.

Table 4. Activities for disseminating the PULCHRA results

Activity	Description	Resources needed	Location
First Open School event – 21.12.2022	First Open School event, to present our project -cca 1 hour and a half	Computers and a stable source of Wi-fi Students, teachers, stakeholders, PULCHRA Romania staff School platform- Google Meet@cnghsincai.ro	Online

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Facebook Page posts	<p>-Introducing the project to general public</p> 	Computer/laptop/smartphone, internet connection	Online
School website posts	 		
Second Open school event- Public	Meeting involving public and school community	Invitation posters, oral and powerpoint presentation on project results	Online

event 01.07.2022	<p>eveniment final PULCHRA Extern Mesaje primite x</p> <p> CONTESINA RUSU <rusu.contesina@cnghsincai.ro> c�tre eu, Mihaela, Lavinia, Marinela, stancu, tomescu ▾</p> <p>Bun� ziu�,</p> <p>Echipa. Colegiului Na�ional "Gheorghe �incai" v� invit� s� participa�i vineri, 1.07.2022. PULCHRA desf��urat �n acest an �n �coal�. Evenimentul va avea loc online. Mai j�</p> <p>Pentru a participa la �nt�lnirea video, d� clic pe acest link: https://meet.google.com/...</p> <p>Pentru a participa telefonic, formeaz� +1 727-914-9571 �i introdu acest cod PIN: 8</p> <p>V� dorim o zi frumoas� pe mai departe!</p>	<p>Computer and WI-fi conection</p> <p>School platform- Google Meet @cnghsincai.ro</p> <p>Participants: students, teachers, PULCHRA staff, stakeholders, mentors and collaborators</p>	
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Lessons from the City Challenge approach

After completing our research, we can say that participating in observation and methodological analyses, following observation protocols, evaluating experiments and evidence-based reasoning increases students' sense of familiarity with the scientific approach, builds confidence in their own ability to engage in science-specific work, and gives students participating in the project responsibility and self-confidence. This was also confirmed by the answers that last year's pupils participating in the project gave to the PULCHRA event evaluation questionnaire administered at the beginning of this school year.

More informations about our project activities can be found on our PULCHRA Facebook Page: <https://www.facebook.com/Pulchra-CNGh-Sincai-102785075323552> and PULCHRA Instagram Page (<https://www.instagram.com/cnghsincaipulchra/>).

References:

- [1] <https://www.europarl.europa.eu/news/en/headlines/society/20180328STO00751/eu-waste-management-infographic-with-facts-and-figures>
- [2] <https://business-review.eu/greenrestart/the-state-of-waste-management-in-romania-plenty-of-work-remains-to-be-done-212632>
- [3] <https://www.eea.europa.eu/ro/themes/urban/about-the-urban-environment>
- [4] http://www-old.anpm.ro/files2/Capitolul%207%20-%20Deseuri_20091227450.pdf

Project Leader from "Gheorghe  incai" National Highschool

RUSU CONTESINA MARIA