

# EVALUATION OF AN URBAN HIGH SCHOOL REGARDING ITS ABILITY TO IMPLEMENT THE PRINCIPLES OF GREEN CHEMISTRY IN THEIR SCIENCE CLASSES



NEW YORK STATE DEPARTMENT OF ENVIRONMENTAL CONSERVATION



Department of  
Environmental  
Conservation

## Case Study: New York City - New York State Green Chemistry School Candidate High School for Health Professions & Human Services

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**High School for Health Professions & Human Services** – Assistant Principal Donna Lopiccio, Chemistry teachers: Harika Celtikcilioglu, Sadia Khan, Modupi Tsetetsi, Rocheli Apilan, Sudip Saha, Aleksandra Gorski.

#### **Disclaimer:**

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*“Evaluation of an urban school district regarding its ability to implement the principles of green chemistry in their science classes”*

### **ABSTRACT**

The primary goal of the grant program “Pollution Prevention Practices at NYS Schools with a Focus on Green Chemistry” is to promote green chemistry and proper chemical management in schools. A secondary goal is to provide insights to stakeholder groups of the benefits of green chemistry and to provide evidence of those benefits, in terms of toxicity reductions and cost savings that can be achieved through chemical management and green chemistry. The objective of the individual case studies is to determine whether or not the chosen school has the capability and commitment to implement the principles of green chemistry in their school. It is evident that the overall objectives of the grant program as well as the objectives of the individual case studies have been met. As a result of this program, the principles of green chemistry have been advanced, stakeholder groups have been made aware of the benefits of green chemistry through toxicity reduction and cost savings, and green chemistry principles have been implemented in high school chemistry classes.

### **INTRODUCTION**

The goal of this case study is to ascertain whether or not High School for Health Professions & Human Services (HSHPHS) can benefit from proper chemical management and the implementation of the principles of green chemistry. Additionally, a function of this study will be to provide evidence of the benefits, in terms of toxicity reduction and cost savings that can be achieved through chemical management. The results of the case study will also be used to illustrate the benefits of partnerships between tertiary level educators and their institutions and teachers in the secondary school system. It is anticipated that the case studies can be used as educational tools to illustrate the benefits of proper chemical management and green chemistry to key stakeholder groups.

The High School for Health Professions and Human Services is a large, urban, public high school with a “high needs to resource ratio” as categorized by the New York State Education Department (SED) School Report Card. It is located in New York City in the borough of Manhattan. The school has approximately 1700 students in grades 9-12, with an average of 400 students per grade. The high school offers multiple levels of chemistry as well as other sciences.

The study was undertaken in steps: The first step was an evaluation of the necessity for assistance which includes a site investigation by New York State Department of Environmental Conservation (DEC) Toxics Reduction & Green Chemistry (TRGC) staff, to determine if the school was a viable green chemistry candidate. The second step included a commitment by school administration and staff to take the necessary steps to implement the principles of green chemistry for one calendar school year in their chemistry classes. The third step included completing green chemistry training conducted by TRGC staff and Beyond Benign, a non-profit organization contracted by DEC. The fourth and final step was having

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the candidate school report back to DEC on their teaching results after implementing the principles of green chemistry in their high school classes.

This project was funded by a grant from the United States Environmental Protection Agency, Region 2 (USEPA), administered by the Division of Materials Management's Toxic Reduction and Green Chemistry Section of the DEC.

### **STEP ONE – SITE INVESTIGATION AND ANALYSIS**

On January 8, 2013, staff from the DEC conducted a preliminary site visit at The High School for Health Professions & Human Services to determine the scope of the chemical usage, storage options, and purchasing practices and to gauge interest by the school personnel in participating in this project.

There are two regulations which impact science areas in schools. One regulation comes from the State Education Department (SED). SED requirements specify locked and secure chemical storage rooms and cabinets. In addition, chemical inventories must be updated at least annually and kept in a secure location. The other is Occupational Safety and Health Administration (OSHA)'s "Laboratory Standard 29 CFR 1910.140", which the authority has been delegated to the New York State Department of Labor under a state plan. This is a more comprehensive regulation, which seeks to reduce significant risks associated with hazardous chemical exposure in a manner appropriate to laboratories. The goal of this project was not to try to enforce the OSHA laboratory standard or any regulations under the NYS Department of Labor.

The High School for Health Professions and Human Services is housed in the former Stuyvesant High School building. There are three schools that share the building. The building itself was constructed in 1904 and was used as Stuyvesant High School until 1995. In 1997, the High School for Health Professions and Human Services was created.

The lab room is small; however, it is a highly functional room that contains many workstations which can accommodate up to 30 students. It has the required safety equipment, such as goggles for student use, eye wash fountains, safety shower, fume hood, and a secure, limited access chemical storage area, which is located across the hall from the lab space.

The school conducted a complete cleanout of the existing chemical storage room in 2011. At that time, there were many chemicals that had been left behind by a former teacher. With changes in the curriculum, these chemicals were no longer needed and were subsequently disposed of through the New York City Department of Education. This school did not require assistance from TRGC with its chemical management but was seeking a more innovative approach to chemistry to motivate its students.

The school's current chemical inventory is small, managed by the licensed laboratory technician. He has the ability to order chemicals as needed as opposed to ordering in bulk at the beginning of the school year. This is a preferable way in which to stock a chemical storeroom as it reduces the number of chemicals in storage.

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No chemical inventory was required as this school had a full time person in charge of ensuring that the inventory was kept at a manageable level. In addition, most New York City schools lack sufficient space to store chemicals.

### **STEP TWO – ACCEPTANCE AND COMMITMENT**

Upon hearing and reviewing the results of the initial assessment by TRGC staff, with a thorough explanation of the benefits of taking part in the program, the High School for Health Professions and Human Services administrative staff and faculty expressed their commitment, for one calendar school year, to take the necessary steps to implement the principles of green chemistry in their chemistry labs.

### **STEP THREE – TRAINING**



*Teachers from NYC working at green chemistry*

#### **Green Chemistry Labs provided by Beyond Benign for workshop:**

- Reactions Lab
- TAML
- Blackberry Solar Cell
- Sublimation
- Catalysis and Oxygen
- Equilibrium/Le Chatelier's Principle
- Exothermic & Endothermic
- Green Precipitation Reaction
- Flame Test

#### **Green Chemistry Training**

The fourth DEC green chemistry workshop, offered to New York City science teachers, was held on March 21, 2013 at Cooper Union in Manhattan. The Institute for Sustainable Design at Cooper Union is committed to a strategy that addresses ecological and social concerns by bringing sustainability to the forefront of their educational agenda. The DEC was pleased to partner with Cooper Union in order to host this important workshop.

The purpose of the green chemistry workshop was to offer training to high school teachers on how to infuse the principles of green chemistry into a traditional high school level curriculum. For this workshop, a green chemistry laboratory booklet was created by Beyond Benign staff, replacing traditional laboratory activities with more benign chemicals and procedures.

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Schools Represented	Boroughs/County	Number of Teachers	Professional Titles
Yeshiva of Flatbush & Sheepshead Bay HS	Brooklyn	1	H.S. Chemistry
Rachel Carson HS for Coastal Studies	Brooklyn	1	H.S. Chemistry
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Renaissance HS Musical Theater & Technology	Bronx	1	H.S. Chemistry
New Explorers HS	Bronx	1	H.S. Chemistry
Bronx Career and College Prep	Bronx	1	H.S. Chemistry
HS of American Studies at Lehman College	Bronx	1	H.S. Chemistry
<hr/>			
H.S. for Health Professions & Human Services	Manhattan	6	H.S. Chemistry
Manhattan District Schools	Manhattan	1	H.S. Chemistry
HS for Environmental Studies	Manhattan	2	H.S. Chemistry
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East Rockaway H.S.	Queens	1	H.S. Chemistry
H.S. for Arts & Business	Queens	1	H.S. Chemistry
William Cullen Bryant HS	Queens	1	H.S. Chemistry
Scholar's Academy	Queens	1	H.S. Chemistry
John Brown HS	Queens	2	H.S. Chemistry
Newcomers HS	Queens	2	H.S. Chemistry
Cathedral Prep Seminary	Queens	2	H.S. Chemistry
Academy of Finance & Enterprise	Queens	1	H.S. Chemistry
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Curtis H.S.	Staten Island	1	H.S. Chemistry
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St. John the Baptist HS	Suffolk County-Long Island	1	H.S. Chemistry
Center Moriches HS	Suffolk County-Long Island	1	H.S. Chemistry
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Saunders Trade & Technology HS	Yonkers, Westchester County	1	H.S. Chemistry

**Workshop Attendance:**

40 people attended the DEC Green Chemistry Workshop, including 30 science teachers representing the five boroughs (Manhattan, Brooklyn, Bronx, Queens and Staten Island) of the New York City Metropolitan area of the state, including three teachers, respectively from Long Island and the City of Yonkers.

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### RESULTS OF GREEN CHEMISTRY WORKSHOP

An overwhelming consensus expressed by the participants on what they liked most about the workshop was the “hands on” green chemistry laboratory stations that were set up around the classrooms. All of the teachers who attended said that they will be using the green chemistry labs in their classes after the workshop. One teacher said, “*It was better than I expected. I thought it would enlighten me somewhat, but now I am inspired*”.

The workshop participants indicated that they liked the ability to network and discuss the experiments as they worked the stations. They were highly satisfied with the green chemistry replacement experiments and handouts and their practical applications. They appreciated the enthusiasm and knowledge of the presenters and the quality of the handouts. They appreciated the emphasis on how chemistry can find solutions without producing toxic and hazardous conditions. Participants liked the simplicity, practicality and safety of the green chemistry experiments.

As with the other workshops, the attendees indicated that they would prefer more “hands on” lab work. They also indicated that they would like to see the number of days and depth of content increased for the workshop. They indicated that they would have been better prepared if they had access to more green chemistry information before the workshop. Many participants indicated that certain topics were missing from the workshop. These included: Green chemistry experiments that would address bio-fuels that relate to cooling curve for steric acid replacement.

### STEP FOUR-IMPLEMENTATION OF GREEN CHEMISTRY IN THE CLASSROOM

After the green chemistry workshop, the High School for Health Professions & Human Services chemistry teachers implemented two green chemistry lab experiments in May-June, 2013. In the fall of 2013, eight more green chemistry experiments were implemented during their laboratory sessions.

- 1. Green Chemistry Lab Highlighting Le Chatelier’s Principle-** This experiment replaces toxic chemicals by everyday non-toxic materials such as black tea and vinegar.
  - In their current experiment, the chemistry teachers from the High School for Health Professions & Human Services teach adding stress to the reactants and products side, by adding or reducing the quantities of the substance on either side of the equation. In this green chemistry version of the experiment, the chemistry teacher felt demonstrating the effects of temperature on a reaction was an important concept they did not ordinarily emphasize. In addition, the fact of using starch and iodine instead of harsh chemicals was a plus!! The green chemistry experiment version of this experiment had a relatively simple set up and procedure, yet the learning experience was profound.
  - In demonstrating the effects of acids and bases on equilibrium, the teacher substituted cabbage juice instead of the recommended tea. She found tea did not produce a distinct color change and therefore the expected results were not as obvious.
  - The chemistry teachers felt that more questions were needed, so they are adding more questions which require students to “cite evidence” and “explain” their reasoning.

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2. **Green Chemistry Experiment Highlighting Catalysts and Oxygen** –This experiment replaces manganese dioxide to demonstrate the effect of a catalyst can improve the efficiency of a process. The “green” catalysts they used for this experiment are yeast, potatoes and liver.
  - The chemistry teachers would like to obtain actual values instead of indicating if bubbling is present or absent. For example, the lab, as it is, requires students to observe the formation of bubbles. Since they would like students to obtain values, they would use Vernier equipment to test the effects of different catalysts on the rate of a reaction.
3. **Intermolecular Forces of Attraction**
  - This experiment was problematic, resulting in teacher innovation to arrive at a workable solution. There were issues with vinegar and alcohol, especially the rate of evaporation. Students had observations that were not consistent with the teachers’ findings. The teachers are looking for alternative “green” substances which can be substituted with better and clear results.
4. **Physical and Chemical Changes** – This experiment worked well.
5. **Conservation of Matter**– This experiment worked well.
6. **Separation of Components in Mixtures**– This experiment worked well.
7. **Role of Energy in a Chemical Change**– This experiment worked well.
8. **Gas Laws**– This experiment worked well.
9. **Properties of O<sub>2</sub> Gas**
  - This experiment was problematic, resulting in teacher innovation to arrive at a workable solution. Vitamin C did not react properly, yielding minimal production of gas. In its place, the teachers used activated yeast with peroxide to get the desired outcome.
10. **Relative Abundance & Atomic Mass of Beryllium**– This experiment worked well.

### **Teachers Observations:**

Students were able to follow the procedures and perform the experiments within the allotted time. Not only were the students following the easy-to-read procedures, but all of them were actively engaged when carrying out these green chemistry experiments. The teacher did make sure to inform the students ahead of the experiments why they were “green” and their lesser impact on the environment, and how this benefits future generations.

The teachers concluded that using green chemistry experiments enabled them to focus on purchasing more naturally-made substances, such as using cabbage juice as an indicator. It was a relief not to worry about toxic chemicals being used which could jeopardize their health and harm the environment.

Teachers found green chemistry experiments to be cost-effective, as most of the chemicals being used are biodegradable; less expensive to buy, less expensive to dispose of.

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As one teacher noted, *“With all these benefits who in their right mind would not continue to use the principles of green chemistry in their labs. All of us here at HSHPHS are most appreciative of integrating Green Chemistry principles and will continue to expand and enhance them into our curriculum.”*

### **OVERALL SUMMARY AND CONCLUSION**

The goals of this case study were accomplished. The overall methodologies used for this case study indicates that the format works. The inventory, training and actual implementation of the green chemistry principles has allowed TRGC to evaluate the program and make the necessary changes to improve it for the next phase. The school showed that they were capable of working in a cooperative manner with the TRGC and made the commitment to implement green chemistry practices.

The study showed that the school benefitted from proper chemical management practices as the chemical inventory was small and up-to-date. The school had previously completed a clean-out of the chemical storage room in 2011. Unwanted chemicals were previously disposed of with assistance by the New York City Department of Education and the school did not require assistance from DEC. This school had a certified laboratory technician ensuring that the inventory was kept at a manageable level. The OSHA Lab Standard mandates that each laboratory have a Chemical Hygiene Officer. This school had a person in a similar capacity to that of a Chemical Hygiene Officer, and this was the main reason that the school's chemical inventory was up-to-date and manageable. Another significant reason may be the fact that schools in New York City lack the storage capability that more modern suburban/rural schools have and are forced to keep inventories low. Additionally, the New York City Board of Education has published a Science Safety Manual, which mandates adherence to OSHA regulations and requires that schools have a Site Safety Officer and Chemical Hygiene officer on staff. It is worth noting that this school was the only school in the study to take this approach.

The workshop and training held as part of this case study enabled 30 science high school teachers representing all 5 boroughs of New York City and 10 observers from interested stakeholder groups to become aware of the benefits of proper chemical management and the principles of green chemistry.

What stands out in this case study is the number of green chemistry experiments tried by the team of teachers in this school. When the experiments didn't quite work out in a real life lab situation, the teachers went on to innovate and adapt solutions. It was probable that teachers took a team approach and contributed feedback to each other in this process. In addition, the school has a licensed laboratory technician that is responsible for the ordering of the chemicals, chemical inventory, and preparation of the solutions used by the teachers and disposal of chemicals. As a result, teachers can focus more on teaching instead of lab preparation.

It is also notable to mention that all the teachers were strongly supported and encouraged to use these green chemistry experiments and principles by their Assistant Principal. This highlights the importance of having administrative support to the teachers when engaging in a new curriculum model. It is very likely, with this input from the chemistry teachers from the HSHPHS, to conclude that these teachers will continue using the principles of green chemistry and expand on the green chemistry experiments that were “road-tested” in this case study.

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**ADDITIONAL GREEN CHEMISTRY RESOURCES:**

<b>Organization</b>	<b>Internet Address</b>
Siena College <ul style="list-style-type: none"><li>• Green Chemistry Summer Institute</li></ul>	<a href="http://www.sienagreenchemistry.org">http://www.sienagreenchemistry.org</a>
Beyond Benign <ul style="list-style-type: none"><li>• Green Chemistry Curriculum (free)</li></ul>	<a href="http://www.beyondbenign.org">http://www.beyondbenign.org</a>
American Chemical Society's Green Chemistry Institute for educators and students <ul style="list-style-type: none"><li>• Experiments and Curriculum for download</li><li>• List of ACS books on Green Chemistry</li></ul>	<a href="http://www.acs.org/greenchemistry">http://www.acs.org/greenchemistry</a>
Greener Educational Materials (GEMS) Database thru the University of Oregon for educators and students <ul style="list-style-type: none"><li>• Searchable database with Green Chemistry education materials uploaded by faculty members and educators worldwide</li><li>• Most curriculum is available for download (free) or with primary literature information</li></ul>	<a href="http://greenchem.uoregon.edu/gems.html">http://greenchem.uoregon.edu/gems.html</a>
GCEdNet-Green Chemistry Education Network	<a href="http://cmetim.ning.com/">http://cmetim.ning.com/</a>
University of Scranton Greening Across the Chemistry Curriculum <ul style="list-style-type: none"><li>• Green Chemistry Modules for download</li></ul>	<a href="http://www.scranton.edu/faculty/cannm/green-chemistry/english/drefusmodules.shtml">http://www.scranton.edu/faculty/cannm/green-chemistry/english/drefusmodules.shtml</a>
Carnegie Mellon University Institute for Green Science <ul style="list-style-type: none"><li>• Green Chemistry Modules for download</li></ul>	<a href="http://igs.chem.cmu.edu/">http://igs.chem.cmu.edu/</a>

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**REFERENCES:**

United States Environmental Protection Agency (USEPA) – [www.epa.gov/region2](http://www.epa.gov/region2)

New York State Education Department (SED) – [www.nysed.gov](http://www.nysed.gov)

Beyond Benign – [www.beyondbenign.org](http://www.beyondbenign.org)

NYC Department of Education – <http://schools.nyc.gov>

The Cooper Union – [www.cooper.edu](http://www.cooper.edu)

High School for Health Professions & Human Services – [www.hphsnyc.org](http://www.hphsnyc.org)

OSHA Laboratory Standard (29 CFR 1910.1450) – [www.osha.gov](http://www.osha.gov)

New York State Plan for Public Employee Safety and Health (PESH)  
– [www.osha.gov/dcsp/osp/stateprogs/new\\_york.html](http://www.osha.gov/dcsp/osp/stateprogs/new_york.html)

NYSED C& I (Curriculum and Instruction) – [www.p12.nysed.gov/ciai/mst/scirg.html](http://www.p12.nysed.gov/ciai/mst/scirg.html)