# Technical Articles

# Improvement of Flood Control Facility through the Development of Automatic Trash Rake

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### Abstract

In response to the flooding caused by excessive garbage in the waterways, the Department of Science and Technology (DOST) through the Metals Industry Research and Development Center (MIRDC), and in cooperation with the Metro Manila Development Authority (MMDA) and the Local Government of Quezon City, developed the Automatic Trash Rake Facility, which is seen as an effective garbage collection mechanism. The Local Government of Quezon City expressed its desire to rehabilitate the San Juan River. Quezon City is one of the first local government units in the country to develop a Disaster Risk Reduction and Management Plan that elaborates the city's preparedness, response, prevention, mitigation and rehabilitation during calamities and disasters.

### 1. Introduction

The DOST, through the MIRDC, implemented the project entitled, "Improvement of Flood Control Facility through the Development of Automatic Trash Rake (ATR)." The trash rake facility was installed at the Balinghasa Creek along Gregorio Araneta Avenue corner Mauban Street in Barangay Manresa in Quezon City. It is an inclined conveyor-type garbage collection mechanism intended to improve garbage collection, which is a better version as compared with the manual method used in the past. The ATR was developed by a group of engineers from the Metals Industry Research and development Center (DOST-MIRDC), Project Management and Engineering Design Services Office (PMEDSO), the Metro Manila Development Authority, Quezon City's Department of Engineering (DOE), Special Design Group (SDG), Environmental Protection and Waste Management Department (EPW-MD), and Task Force Waterways (TW). The use of this technology has enabled the collection of waste in waterways faster and easier, especially during the rainy season.

The facility is capable of collecting an average of 5.1 cubic meter of trash in an 8-hour shift and has its own backup generator and three trained operators. It was installed to collect garbage before the water goes to adjoining major creeks leading to the San Juan River. The Balingasa Creek is a main tributary to the San Juan River and 86 percent of the wastes from upstream pass through it.

The setting up of the facility has remarkably abated clogging of the San Juan River and reduced the amount of debris washed out in Manila Bay during typhoons. Quezon City environmental management executives believe that the clogged Balingasa Creek was the cause of severe flooding in Barangays Masambong and Manresa, and also as far as Talayan Village and along the stretches of Araneta Avenue. During the initial 2 months of endurance and performance testing of the facility, which ran from October to December 2014, the ATR has already collected an average of 4 cubic meters per day during dry season and 6 cubic meters per day when it rains. The Quezon City government initially provided 3 personnel to undergo training on operation and maintenance of the facility. These personnel are part of Quezon City's commitment for the sustainability of the facility after the turnover.

### 2. Review of Related Literature

Trash rakes have existed since the first hydroelectric power plants were developed. Used to clean the intake racks that prevent debris from entering the plant, trash raking can be done as either a manual or automated process. While manual cleaning is still commonly used, automated systems are becoming more widely used because of their increased efficiency and lower operational costs.

Trash rack cleaning poses many challenges to the operators of hydroelectric plants. As outlined in Civil Works for hydroelectric facilities, published by the American Society of Civil Engineers (ASCE) in 2007, these problems include:

• Siltation, which occurs when twigs, branches and leafy materials are not removed properly, causing an increase of sedimentation on the trash rack.



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- Lower efficiency, caused by a damaged raking arm or misaligned trash rake.
- Damaged cables or pulleys.
- Inadequate lifting capacity.
- Inability to reach the bottom of the trash racks. (Hand raking is limited to depths of 6 to 8 feet below the water's surface.)

### 2.1 Design of Automated Trash Rake Cleaning Systems

Automated trash rakes can handle debris with great efficiency, either by dumping it on the fore bay or intake deck, or through a conveyor or trough. Automated raking systems can be initiated based on time or a head differential. A buildup of trash creates an increased differential head across the trash rack; the rake begins operations when a specific level is reached. Automated systems can also be initiated manually by an operator who can watch for certain conditions and trigger the rake, when necessary.

Lives and properties are lost and destroyed every year especially at coastal areas and at seas due to destructive waves, strong winds, and storm surges that is brought about by the inclement weather conditions.

### 2.2 The Benefits of Automated Trash Rakes

The San Juan River straddles Quezon City, San Juan, Manila, and Mandaluyong. Its entire basin including its tributaries has a catchment area of 90.4 sq. km. comprising the lower half of Quezon City, the City of San Juan and parts of Mandaluyong City, Pasig City and Manila City. Of the total area, about 78 sq. km. is located in Quezon City.

The San Juan River is approximately 10.581 kms starting at Quezon Avenue in Quezon City, passing thru Manila and San Juan City and ending at the Mandaluyong City part of Pasig River. The City of San Juan occupies roughly 2 kilometers of the river. The barangays located beside the river are Salapan, Rivera, Progreso, Balong-Bato, and Batis.

The main cause of flooding in some barangays in the city is the heavily-silted San Juan River where most of the garbage that flows from upstream Quezon City travels down to San Juan, Mandaluyong, and Manila, and eventually ends up in Pasig River. A certain amount of thrash and garbage from the last three cities also pose a problem. With the construction of the Automatic Trash Rake Facility, upstream garbage can be collected before it enters the other tributaries, creeks and canals downstream. With this technology, the risks of flooding brought by clogged drainage system can be reduced.

### 2.3. Binondo Pumping Station

President Benigno S. Aquino III inspected the Binondo Pumping Station and discussed alternative means to improve its operations to mitigate flooding problems in the city. He instructed Metro Manila Development Authority (MMDA) officers headed by Chairman Francis Tolentino, to seek alternative measures to de-clog waste materials caught in the drainage system. He further suggested to the agency to seek alternative technology from the Department of Science and Technology (DOST) to help solve flooding problems.

Manila, being at sea level, is prone to flooding during rainy season, with areas being submerged in just few hours of rainfall. Although much of its flooding problems can be attributed to its land feature, i.e. its flood-prone areas are below sea level, Manila's poor waste management has been the identified primary cause. It's pumping station's performance is down to 60% due to accumulated waste materials from informal settlers residing in the creeks and canals.

The MMDA currently operates and manages 51 pumping stations - 21 large pumping stations, 10 small pumping stations and 20 relief pumping stations.

### 2.4. Project Management Team

The Project Management Team was composed of the following with their corresponding responsibilities:

1. Metals Industry Research and Development Center (MIRDC) - The agency assigned to implement all the activities from materials/suppliers procurement for the construction and development of the Automatic Trash Rake Facility; hiring of manpower, design, coordination with Quezon City Local Government Unit and other stakeholders, and overall project management.

2. Project Management and Engineering Design Services Office (PMEDSO) - In-charge in the specification requirements of the Automatic Trash Rake Facility and assisted in the project management and coordination with different agencies and other stakeholders.

3. Philippine Council for Industry, Energy and Emerging Technology Research and Development (PCIEERD) - The agency tasked to monitor the overall progress of the project and assisted in the coordination with different agencies and stakeholders.

### 3. Methodology

### 3.1. Consultation with partners, stakeholders, and beneficiaries of the Project Output

Engineers from PMEDSO and MIRDC collaborated with the Quezon City Engineering Department and Metro Manila Development Authority to establish a structural design of the automatic Trash Rake Facility. The initial prototype was installed at the center of G. Araneta avenue corner Mauban street, Quezon City which was identified by the by the MMDA and Quezon City's Task Force Waterways and Environmental Protection and Waste Management Department (EPWMD) as one of the main contributors of garbage which was coming from Balintawak market and nearby residence. The project Improvement of Flood Control Facility through the Development of Automatic Trash Rake aims to collect the garbage from upstream creek before it goes to major creeks of the San Juan River.

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The Site

### Figure 1. Vicinity Map of Automatic Trash Rake Facility

## 3.2.Conduct research and development to address the technology inputs needed

In coordination with the Metro Manila Development Authority, the Project team conducted meetings with the MMDA-Quezon City officials for the identification of possible site location for automatic trash rake. Several locations were visited to finalize the location and determine the final specification of the trash rake. The possible sites are Balingasa Creek, Culiat Creek, Pasong Tamo Creek and Dario Creek.

For every site inspected, the project team conducted basic data gathering, such as measuring the creek's width, length and depth for documentation and for the design of the proposed automatic trash rake facility. Also, the team considered the sustainability of the facility, such as storage of garbage collected, accessibility of garbage truck during collection, and number of barangays served.

The team visited several pumping stations of the MMDA for bench marking. These include Binondo, Taguig, Buendia, Libertad and others. Visiting the pumping stations will reduce the design development timeline since the existing trash rake of MMDA is already proven as working. Initial design were discussed with the MMDA engineers for their comments and suggestions prior to finalization. Together with the MMDA staff, the final location was identified.

### 3.3 Identification of final location

The MIRDC Trash Rake Team had a presentation of the Automatic Trash Rake design to be constructed in Balingasa Creek, Quezon City to the Engineering Department and the Environmental Protection and Waste Management Department (EPWMD) of the Local Government Unit of Quezon City (LGU-QC).

The site, the creek located in the center island of Gregorio Araneta Avenue and intersection of Mauban Street, was surveyed and studied for suitability of installing the trash rake facility. The data collected are to be used for the documentation, preparation and planning of the design of the proposed automatic trash rake and structural design of required civil works.

### 3.3.1 Site General Information:

The Balingasa Creek is located in the center island of Gregorio Araneta Avenue and intersection of Mauban Street in Quezon City. The site descriptions are as follows:

- The width of the creek is 6.30 meters;
- The depth of water level from the ground level is 2.70 meters;
- The creek's wall is lined-up with concrete hallow blocks (CHB) wall;
- A steel pipe is installed, along the creek;
- The creek is in between the two (2) roads;
- Possible access for dump truck;
- The proposed site is surrounded by numerous inhabitants.

According to some respondents, the accumulated garbage in Balingasa Creek is from Balintawak Public Market as shown in Figure 2.

Prior to the start of the final structural design, a soil test analysis was conducted to determine the soil bearing capacity of the location. The result of the said test is the basis for the final design of the foundation of the facility.



Figure 2. Source of Accumulated Garbage in Balingasa Creek

### 3.4. Design of the Automatic Trash Rake Facility

The initial design of the Automatic Trash Rake Facility passed through a series of review before it was finalized. With the support of Quezon City's Special Design Group headed by Architect Virgilio Regala, the final structural design based on the results of the soil test analysis was completed. Aside from structural and construction design, the mechanical side was completed by the MIRDC project team in coordination with the PMEDSO.

### 3.5 Construction, fabrication and installation

Prior to construction, the Quezon City LGU required the project team to present the proposed facility to the Quezon City ManCom to further review the design and to raise any concerns on the facility. Through a Memorandum of Agreement, the MIRDC represented by then Asec. Robert O. Dizon and the Quezon City LGU represented by Honorable Mayor Herbert M. Bautista signed the said MOA which identifies the roles of both parties during and after the duration of the project.

The NORTHWELL CORPORATION was awarded the contract amounting to Six million four hundred ninety eight thousand five hundred Pesos (Php 6,498,500.00). The construction, fabrication and assembly must be completed to the satisfaction of MIRDC within 120 calendar days reckoned from the date of receipt of the Notice to Proceed. Because of construction delays, the Northwell Corporation requested for additional 26 days (September 5 to September 28, 2014) extension period; the delay is due to intermittent working schedule during construction caused by the rainy season and typhoons. The construction was completed within the approved extended duration.

### 3.6. Testing and Training

After the completion of construction, fabrication and installation last September 30, 2014, the project team conducted initial testing of the equipment. Together with the PMEDSO, the team conducted functional testing for 1 week and was witnessed by the Quezon City Engineering Department. After the functional testing, the project team requested the Quezon City LGU to provide personnel to be trained parallel to the testing of the equipment. The Quezon City LGU provided 3 personnel for the operation and maintenance of the facility. The training is planned for 3 months starting November 2014. During the 3 months operation of the facility from November 03, 2014 to February 03, 2015, the automatic trash rake facility already collected an average of 5.4 cubic meters of garbage even if there is no rain and 6.25 cubic meters when there is rain.

### 3.7. Launching of the Automatic Trash Rake Facility

The launching of the automatic trash rake facility was held on December 2, 2014 at the second floor of the Civic Center Building C of the City Hall compound.

The event was attended by Mayor Herbert M. Bautista, DOST Secretary Mario G. Montejo, Engr. Robert O. Dizon, OIC, MIRDC, Engr. Jonathan Q. Puerto, Deputy Executive Director for Research and Development, Dr. Teresita C. Fortuna, DOST-NCR Director, PCIEERD Executive Director Dr. Rowena Cristina L. Guevara, representatives from the Metropolitan Manila Development Authority (MMDA) and the Department of Public Works and Highways (DPWH), EPWMD head Frederika Rentoy, and other city officials and guests.

### 3.8. Economic Analysis / Viability

Based on the 2-month initial testing conducted by Quezon City's EPWMD and the MIRDC project team, an average garbage collection rate of 5.2 cubic meters per day was achieved by the ATR with only 2 personnel operating the facility. Compared to manual operation, the cost of labor incurred involving 20 personnel collecting 5 cubic meters a day of garbage from the water ways is greater than the cost incurred in operating the facility including the initial investment of Php 6,900,00.00 for five years operation.

### 4. Results and Discussion

The DOST-MIRDC implemented the project entitled, "Improvement of Flood Control Facility through the Development of Automatic Trash Rake" in response to President Benigno S. Aquino III's pronouncement identifying the DOST as a possible source of alternative technology to help solve the country's perennial flooding problem.

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The primary objective of the project was to design and develop an automatic trash rake aimed to improve flood control that would function as a model unit for the demonstration of an operational Trash Rake Facility. At the end of the project, one trash rake facility was constructed at Gregorio Araneta Avenue corner Mauban Street, Quezon City.

Quezon City environmental management executives believe that the clogged Balingasa creek was the cause of severe flooding in Barangays Masambong and Manresa, and as far as Talayan Village and other areas along the stretch of Araneta Avenue. In coordination with the Quezon City LGU and the Metro Manila Development Authority, the project team was able to decide which is the ideal site and integrated this during the design phase.

The concept design of the Automatic Trash Rake Facility was planned through the collaboration of PMEDSO, MIRDC, Metro Manila Development Authority, Quezon City Local Government Unit. Construction of the ATR facility was done by Northwell Corporation.

### 5. Summary and Conclusion

Towards the completion of the project, in partnership with Quezon City LGU and Northwell Corporation, the Automatic Trash Rake Facility was designed and built at the center island of G. Araneta avenue corner Mauban Street. The automatic trash rake facility was completed through the collaboration of PMEDSO, MIRDC, Quezon City Engineering Department, MMDA and Northwell Corporation.

Since the project team already conducted a series of initial functional testing of the equipment together with the PMEDSO and witnessed by the Quezon City Engineering Team, the project is considered a successful one. The equipment completed its performance and endurance testing for a period of 3 months conducted by Quezon City personnel. The trash rake facility already collected an average of 5.8 cubic meters of garbage a day under a very limited 8 hour per day operation due to lack of personnel.

With the perceived success of the project, the Quezon City LGU expressed interest to construct another 2 facility to further improve its garbage collection performance.

The DOST-MIRDC has officially turned over the management and operation of the automatic trash rake facility to the Quezon City LGU during a brief ceremony held at the Civic Center Building C of the City Hall Compound.

The use of the technology will enable the collection of garbage in water ways faster and easier, especially during the rainy season. The ATR was installed to collect garbage before the water goes to adjoining major creeks leading to the San Juan River.

### 6. Recommendations to Future R&D Works

The Project "Improvement of Flood Control Facility through the Development of Automatic Trash Rake" is a research and development breakthrough in the Philippines. It is the first trash rake facility for creeks and tributaries built and developed by local engineers. As part of its continuous development, below are the recommendations for future R&D works:

1. The trash rake facility must be adopted and deployed in other creeks. The project is geared towards raising public awareness on the governments' research and development initiatives, as well as promotes the ATR as a machine that could help improve trash collection in the waterways.

2. Unmanned facility. A facility with no operator on site. It can be a remote controlled facility or can be operated on pre-programed operation or more complex continuous system operation.

3. A screen type apron plate design for wind and water resistance during typhoon is necessary. The Automatic Trash Rake Facility that was constructed and installed at G. Araneta Avenue corner Mauban St. is a demonstration of an operational automatic trash rake facility. Further promotion of the technology must be pursued.