International Journal of Engineering Sciences 2023 15(4) 167 - 174

INTERNATIONAL JOURNAL
OF
ENGINEERING SCIENCES

Monitoring System for the Management of Technological Waste at the Federico Villarreal National University

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(Received 9 November 2022; Accepted 10 January 2023)

DOI: https://doi.org/10.36224/ijes.150405

Abstract: This research project presents the environmental problem of technological waste management for the Universidad Nacional Federico Villareal and shows how it is possible to monitor the process using an information system to monitor, control, measure and make decisions in each sub-process of technological waste management. The project enables monitoring based on data and information. The recording of collection, storage, reuse and final disposal of waste is important to control the monitoring process and reduce the environmental pollution produced by technological waste. In addition, it implies determining the favourable acceptance to develop and implement a monitoring system to control each of the processes in the life cycle of the technological waste. From the technological point of view, it also presents the chosen development methodology, the process flow of the monitoring management, the modular architecture, the software architecture, the database design of the solution, the design and development of the interfaces based on the requirements.

Keywords: Technological waste; waste management; waste monitoring; monitoring system; software architecture; environmental contamination

1. Introduction

With the growing industry of information technology companies, billions of tonnes of solid electronic waste are generated worldwide every year. The accumulation of waste is growing out of control and may reach 74.7 million metric tons by 2030, according to the United Nations Environment Programme. The management of waste electrical and electronic equipment has become a growing problem worldwide due to the constant and accelerated change of technology, taking into account that a minimal amount is reused once the equipment is discarded [3]. In Peru, the management of waste electrical and electronic equipment is promoted by the Ministry of Environment, in charge of the General Directorate of Environmental Quality, which designs and supervises the application of the laws promoted for the control and environmental protection due to solid waste from waste electrical and electronic equipment (WEEE). [1] Currently, the Universidad Nacional Federico Villarreal (UNFV) has a Waste

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ISSN 0976 – 6693.

Management Plan for electrical and electronic equipment that includes procedures according to national regulations for the management and handling of WEEE and the UNFV's procedures manual based on the regulations of the national superintendence of state goods. The UNFV currently has an environmental commitment; however, it does not fully contemplate the management of waste electrical and electronic equipment; nevertheless, the different departments are also working towards the common objective of reducing environmental pollution. We note as background that, based on the above, the UNFV as a public and educational entity has the responsibility to apply the relevant guidelines for the fulfilment of this socio-environmental policy, but currently the UNFV does not have any system to manage the treatment of this waste, nor does it even have a mechanism to quantify the quantities of WEEE produced. The system it employs consists of leaving a record of the electronic or electrical equipment that has broken down or is no longer in use so that the heritage office can cancel them, so the procedure for treating these elements is no different from the procedure used to treat other types of waste produced by the UNFV, the latter supporting the need to raise awareness and implement mechanisms for the integrated management of WEEE in the educational institution. It is for these reasons that the need arises to implement automated software to be able to manage these resources through an adequate system that allows control over the WEEE and to follow them up from the classification and identification process to their final disposal. This research is justified and important because it will allow us to manage waste, that is, to try to remove from circulation all the components that can generate some kind of threat or damage to public health or the environment, and to recover those essential materials, these can refer to glass, metal or plastic [4]. Waste electrical and electronic equipment contains a vast diversity of chemical components within the variety of electronic equipment, there are up to a thousand different substances, and many of them have high levels of toxicity, including lead, arsenic, cadmium, chromium, selenium, mercury, lithium, biphenium, tetrabromine, beryllium, barium, toner powder, americium, zinc sulphide, among others [2[

Given that the waste generated by the UNFV currently does not receive monitoring in the efficient management of technological waste, which can cause serious environmental problems, in addition today there is no culture and general policy of sustainable management of technological waste within the university population, which can generate a very limited quality of life over time. The objectives of the present research are focused on the development and implementation of a monitoring system for the management of technological waste of the Universidad Nacional Federico Villarreal, which should allow a record of collection, follow them from the process of classification and identification, treatment of technological waste, until its final disposal in the management of technological waste monitoring of the UNFV. In addition: Determine the acceptability of developing a Monitoring System regarding the collection register in the technological waste management of UNFV. Determine the acceptability of developing a Monitoring System regarding the record of storage in the management of technological waste at UNFV. Determine the acceptability of developing a Monitoring System regarding the record of treatment of technological waste management at UNFV. Determine the acceptability of developing a Monitoring System regarding the record of final disposal in the management of technological waste at UNFV.

2 Materials and Method

2.1 Method (Universe and sample, instrument and procedure)

The research will be focused within the qualitative and quantitative paradigm, of a basic descriptive and analytical type, it aims to systematically describe the generation of computer equipment waste, because it seeks to understand the facts from a frame of reference of the actors, allowing to know the study area and the reality of contamination and waste of technological devices. Establishing objective and reliable answers that guide towards

the solution of the problem, after which a solution will be put to it. The research is related to two modalities: bibliographic and field. In the field, because it takes place in the place where the problem occurs. For this purpose, it has had the support and direct participation of those who work at the university, both managers and administrators will participate, with their criteria, in the research, answering the applied surveys. Bibliographic, because it has been used to investigate various sources that contain scientific information related to the fact to focus on the problem, which has been consigned both in the foundation and in the theoretical framework, which constitute main elements of the work carried out. In the study of the investigation, it is determined: the spatial and temporal scope

Space Scope: The research will be carried out in the city of Lima-Peru. Temporary Scope: according to the structure of the research project, it will be developed during the school period (March to December) 2022 According to the methodology, very relevant aspects are considered, such as:

2.2 Universe

Managers and administrative staff of all the faculties of the Federico Villarreal National University are considered. It is part of the universe with the same characteristics, to calculate the sample size the following formula will be applied: Where: Population(N) 1200 people Security 95% probability of success (p) 5% (assumed) maximum admissible error (d) 0.03 (assumed).

$$n_{opt.} = \frac{N \times Z^2 \times p \times q}{d^2 \times (N-1) + Z^2 \times p \times q}$$

For a 95% certainty there is a confidence level (Z) = 1.96 Sample number: 174 selected users

2.3 Instrument

For the collection of information on technological waste and waste, the survey is considered, aimed at managers and administrative staff of all the faculties of the Federico Villarreal National University that the institution has. For which the following will be done. • Systematic review • Documentary analysis • Data Collection Sheet (survey

$$n_{opt.} = \frac{1200x\ 1.96^2\ x\ 0.05\ x\ 0.95}{0.03^2\ x\ 1199 + 1.96^2\ x\ 0.05\ x\ 0.95}$$

$$n_{opt.} = 173.6 \approx 174\ personas$$

For the collection of information on technological waste and waste, the survey is considered, aimed at managers and administrative staff of all the faculties of the Federico Villarreal National University that the institution has. For which the following will be done. • Systematic review • Documentary analysis • Data Collection Sheet (survey)

Data Tabulation • Histogram chart • Process Diagram • Sampling

2.4 Procedure

Once the data collection has been achieved through the survey, it will be processed with the use of the SPSS tool, systems that quantify the results by means of statistical tables and graphs. (Castells, 2009) To do this, the

following will be done: For the data collection procedure, the survey will be applied The accumulation of information in each area will be verified, it will be classified according to its validity. Systematization of the data and information process Review of the data obtained. Analysis and interpretation of data

3 Result

3.1 Representation of results by process and Representation of results by question

The results by process and associated specific processes per scale are presented below: Consolidated result by main question Do you agree with the implementation of a monitoring system for the management of technological waste? Below are the results by the process and specific processes associated by scale: Consolidated result for the main question Do you agree with the implementation of a monitoring system for the management of technological waste? Below are the results by the process and specific processes associated by scale: Consolidated result for the main question Do you agree with the implementation of a monitoring system for the management of technological waste?

Table 01: Scale result

Scale	Total	%
Strongly agree	44	25.3
Somewhat agree	111	63.8
Neither Agree Nor Disagree	5	2.9
Somewhat Disagree	14	8.0
Disagree	0	0.0
Total	174	100.0

Source: Own elaboration

Interpretation: According to table 01, it can be shown that 111 participants agree with the implementation of a system, and none disagree. Here is their graphical representation:

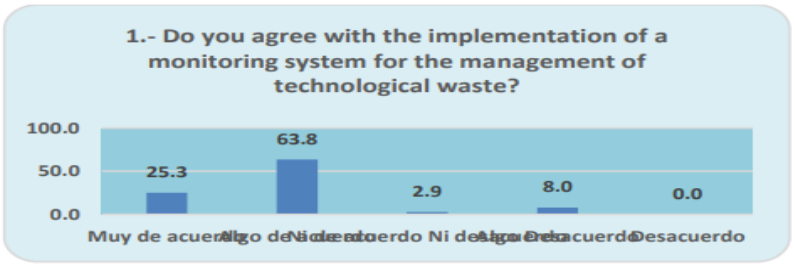

Figure 1: Representation of results to the main question
Source: Own elaboration

3.2 Development

Development Methodology The development strategy of the software project cycle was defined, the predictive model or classic life cycle was determined for the development of the Monitoring Management System according to the following technical support: Prior knowledge of the project, the main activities to be developed of the project have been identified based on the identified requirements, planning details the activities in each phase of project development, requirements are defined before the development starts and are of minimum variability,

Activities are clearly identified between the different phases of the project, generation of documentation about the project in different phases and level of risks and costs are controlled by detailed planning. The same component: Initiation, Planning, Execution, Control and Closure [5].

Figure 2: Methodology for the development of the Monitoring System for the management of technological waste at UNFV

Source: Own elaboration

3.3 Process Definition

Process management was defined and the process flow for the Technological Waste Monitoring System was designed, using as a reference framework the Waste Management and Handling of Waste Electrical and Electronic Equipment of the Ministry of Environment.

Figure 3: Process Management Model for the Monitoring of Technological Waste Source: Own elaboration

3.4 Modular Architecture

The main modules of the Technological Waste Monitoring System were identified, proposing the following modules: Security Module (Access), Administration Module (Profiles, Users, Modules), Technological Product Registration Module, Faculty Maintenance, Warehouse Maintenance, Transport Maintenance, Collection Point Maintenance, Collection Management, Storage Management, Reuse Management, Final Disposal Management and Monitoring Management. In addition to the reporting and consultation module, the modules front-end intranet administration, faculty intranet, faculty environment intranet, waste treatment specialist intranet, final disposal and collection specialist intranet have also been identified.

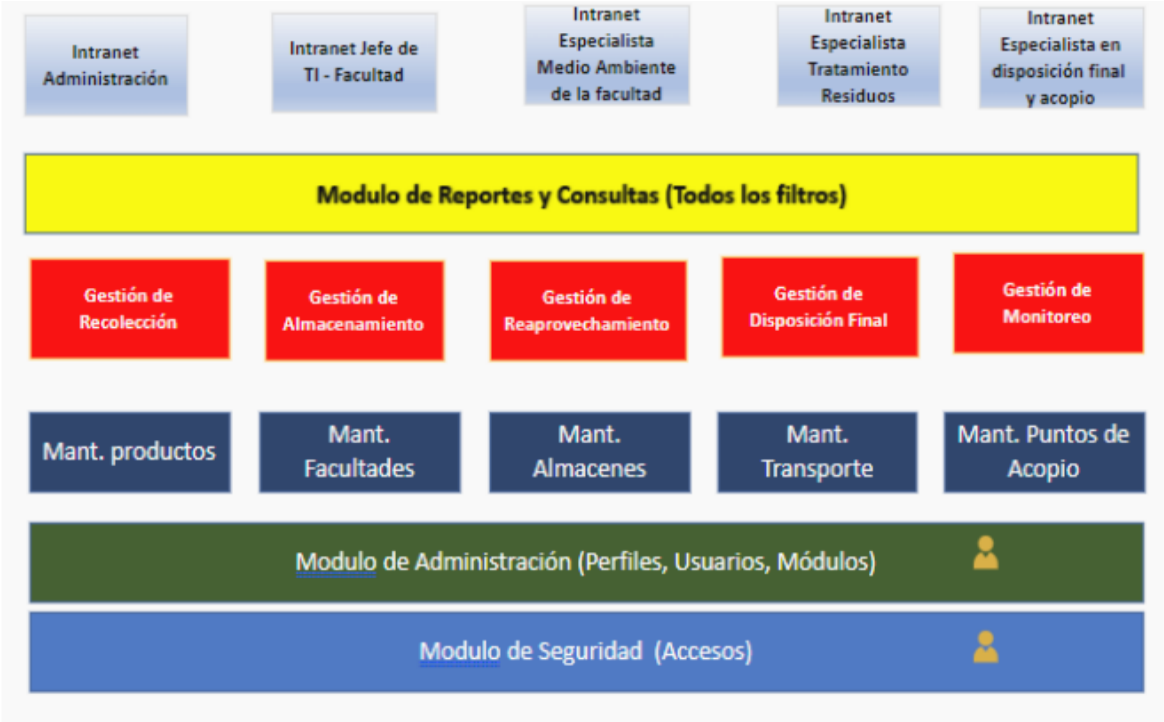

Figure 4: Modular Architecture of the TechWaste Monitoring System
Source: Own elaboration

3.5 Software Architecture

Design of the architecture of the technological waste management monitoring system that will support the system

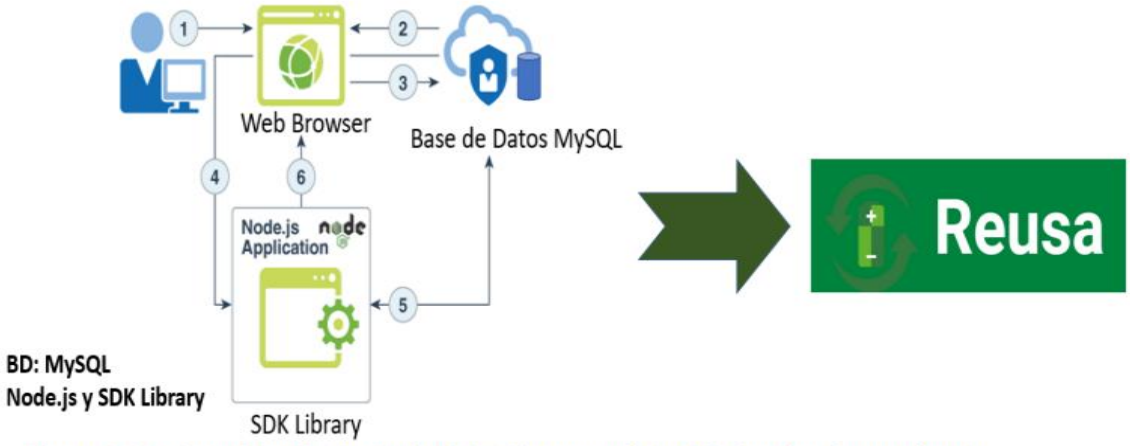

Figure 5: Design of the Technological Architecture of the Monitoring System for the management of technological waste of UNFV

Source: Own elaboration

4 Discussion

As we have appreciated, in general, the assessment of the different tabulations in the presentation of results, shows an acceptance of the implementation of the monitoring system for the management of technological waste, which involve managing their specific processes such as the collection, storage, treatment and disposal of technological waste are acceptable, i.e. "Strongly Agree" and "Somewhat Agree", this implies that it is necessary to take action in the process of technological waste management should be monitored with an information system. Regarding the Development of the Monitoring System, a selection of methodologies has been made, and the one that best fits the conditions and characteristics of the requirement is a cascade methodology, whose main purpose is incremental and interactive. Regarding the monitoring management process, it has been designed according to the life cycle of waste management in general, for this case it has been specified and adapted for the system and the research according to the main process and its subprocesses. Regarding the Modular or Functional Architecture of the System, the different requirements that could be part of the implementation have been collected and considered according to the main process and its sub-processe

Regarding the Software Architecture, the different technologies have been selected according to the requirements of the identified processes, in addition to the scaling and sustainability of the monitoring system. With respect to the requirements implemented, they are in accordance and in relation to the process and sub-processes, also aligned to the objective of the research project and according to the problem statement. As main conclusion: The Monitoring System for the management of technological waste for the Universidad Nacional Federico Villarreal has been developed and implemented. As secondary conclusions: It has been positively determined that the technological waste collection record with the Monitoring System allows measuring, controlling and monitoring based on data and records the management of technological waste. It has been positively determined that the recording of technological waste storage with the Monitoring System allows measuring, controlling and monitoring the management of technological waste based on data and records. It has been positively determined that the technological waste management registry with the Monitoring System allows measuring, controlling and monitoring the waste management based on data and records. It has been positively determined that the record of technological waste final disposal with the Monitoring System allows measuring, controlling and monitoring based on data and records the waste management. Finally, it is recommended to: Carry out the transfer, application and deployment of the Monitoring System for technological waste management at Universidad Nacional Federico Villarreal. Continue to perform data analytics to control, measure and manage the

technological waste collection record with the Monitoring System in the management of technological waste. Continue analyzing data to control, measure and manage the technological waste storage registry with the monitoring system in the management of technological waste. Continue to perform data analytics to control, measure and manage the technological waste management record with the Monitoring System in the management of technological waste. Continue analyzing data to control, measure and manage the record of final disposal of technological waste with the monitoring system in the management of technological waste.

5. References

1. Arevalo, J. (2017). Simulacion del proceso de gestion de los residuos electronicos de la línea gris en la ciudad de Tarapoto para planificar escenarios futuros en el Periodo 2016-2050. Unar.
2. Estada, J. (2015). Reciclaje de Residuos Electrónicos con enfoque Sistémico. Zacatengo, Mexico DF.
3. Parrales, J. (2020). Manejo de desechos tecnologicos en instituciones públicas. Jipijapa.
4. Pineda, D. (2017). Modelo Para La Gestión de Reciclaje de Residuos electrónicos. Académica Española.
5. Quintero, I. (2017). Node.js, Javascript del lado del servidor: manual práctico avanzado. Altaria