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Reception and management of agrochemical containers in the CATs

Recepción y gestión de envases de agroquímicos en los CATs

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Abstract

The handling of agrochemical containers is subject to compliance with current laws for the operation and certification of systems that reduce contamination risks. The objective of this research is to design a computer system that allows greater control in the Temporary Collection Centers (CAT), from the reception of containers to the exit of waste to destination companies. For the development of the project, an exhaustive analysis was carried out in each of the processes. Requirements gathering techniques and the design of diagrams will be applied to detail the context of the processes using the Unified Modeling Language (UML). The database was designed in MySQL and the programming was carried out in Visual Studio 2023. Results were obtained in various reports and statistics that allow managing the capacity of the CATs and having a reliable record of the origin of the containers, as well as a control and follow-up in the exit and delivery of waste to final destination companies. The project is a challenge of environmental impact and social responsibility that requires the intervention of different sectors, public and private, as well as the direct collaboration of agricultural producers.

Agrochemical, Environmental, Intervention, Systems

Resumen

El manejo de envases de agroquímicos está sujeto al cumplimiento de leyes vigentes para la operación y certificación de sistemas que reduzcan los riesgos de contaminación. El objetivo de esta investigación es diseñar un sistema informático que permita un mayor control en los Centros de Acopio Temporal (CAT), desde la recepción de envases hasta la salida de los residuos a empresas destino. Para el desarrollo del proyecto se llevó a cabo un análisis exhaustivo en cada uno de los procesos. Se aplicaron técnicas de recolección de requerimientos y el diseño de diagramas para detallar el contexto de los procesos utilizando el lenguaje de modelado unificado (UML). La base de datos fue diseñada en MySQL y la programación se llevó a cabo en Visual Studio 2023. Se obtienen resultados en diversos reportes y estadísticas que permiten administrar la capacidad de los CAT y disponer de un registro confiable del origen de los envases, así como un control y seguimiento en la salida y entrega de residuos a empresas de destino final. El proyecto es un reto de impacto ambiental y de responsabilidad social que requiere la intervensión de diferentes sectores, públicos y privados, así como la colaboración directa de los productores agrícolas.

Agroquímico, Ambiental, Intervención, Sistemas

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Introduction

Today's agriculture demands a higher level of food production to sustain the world's population through automation and intelligent decision-making to ensure food security, availability of suitable land for crops, perishability of produce, as well as environmental conditions. Data-driven systems benefit all stakeholders. The approach to agriculture implies including initiatives to reduce inequality and the technology gap, extending to all rural and urban areas, implementing state policies to achieve mainstreaming, and promoting access to the Internet (Beltran, 2022).

Auer (2023) comments in his research that the rural sector seeks to balance the use of chemicals with agricultural demand and the health of the population, through the implementation of good agricultural practices in Argentina. The work considered variables related to territoriality, as well as soil analysis, precision agriculture and pest control and pesticide storage, empty container management, among others. The study made it possible to contribute sustainable measures for the protection of the ecosystem through technological innovations implementing alternative models that improve the quality of the products and safeguard the health of the environment and the population.

Ortíz et al. (2014) explain that the Ley General Para la Gestión Integral de los Residuos (LGPGIR) regulates the management of waste, which can be materials or products that are discarded and must be subject to a management plan. The law states that the incineration of organochlorine pesticides is prohibited, as it generates pollutants such as dioxins and furans. The Federal Plant Health Law provides for a National Pesticide Residue Monitoring Programme and its dissemination.

Auer (2023) affirms the importance of the correct management of containers, which implies their collection and assignment to a controlled and identified final destination, as they imply a high risk of toxicity.

Roque (2023) raises the importance of regulating the commercialisation of pesticides in Honduras by the health sector and governmental agencies, since several samplings have detected products with a high level of danger and easy access to them, with a strong impact on public health. As far as the academic sector is concerned, it is invited to participate in activities to disseminate the use, custody and conservation of pesticides in appropriate places without compromising health and the environment.

Madoery et al. (2023) describe in their study the importance of analysing the territorial dynamics that affect land use and land use planning, based on methodologies, techniques, trends, environmental scanning and others, which allow them to visualise possible scenarios. They carried out surveys of peri-urban producers in order to learn about agricultural practices (technologies used, fertilisation, pests, and phytosanitary products used), with the aim of estimating the knowledge of norms, environment and linkages in order to establish action plans and strategies. Five dimensions and their variables were analysed during the diagnosis. In the physical-environmental dimension, the variables analysed were: peri-urban land use, forestation, climate risk, solid waste and effluent management, as well as phytosanitary management. A strategic map was generated to locate impacts, administrative and regulatory processes as well as actions to guide activities to be carried out in different timeframes, including awareness-raising, sensitisation and training. The research they present allows for the prioritisation of critical trends and uncertainties in the space.

In Mexico, in the state of Jalisco, there was previously no computer system in the CATs to efficiently control the reception and management of agrochemical containers, as well as an automated follow-up for the exit of waste to the final destination companies.

The article presents a theoretical framework related to the problem to be solved as well as the computer elements used for the solution, and also includes details of the phases developed in the methodological description. At the end, the results obtained, conclusions and bibliographical references are presented.

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Theoretical framework

Agrochemical packaging

T Chirinos et al. (2020) developed a research to analyse the magnitude of agrochemical use of pests in the most important crops in Ecuador, the research included chemical inputs applied, generic name, active ingredient, acute toxicity and dosage applied, spraying frequency, periods of deficiency and product mixture. The results showed high spraying frequencies, as well as high dosage levels with high toxicity causing imbalances in the agrosystems, as well as significant health and environmental effects. During the research, it was common to observe empty phytosanitary containers abandoned in the fields, which further compromised the ecosystem and the health of the population.

Ortíz *et al*. (2014) describe the regulation of the production, distribution, storage and use of pesticides in Mexico, as well as the consequences and effects on health, locating the places with the highest incidence of morbidity in Mexico. They also present regulations and governmental agencies, civil organisations and research centres involved. However, they comment that despite regulations and restrictions, pesticides represent a serious problem for the health of workers and the population, also generating soil and water contamination. Therefore, it is important to apply regulations on the production, distribution, storage and use of pesticides.

Other research indicates that in Mexico in 2018, more than 61,000 tonnes of pesticides were imported, compared to more than 106,000 tonnes in 2017. The biggest problem in Mexico, as in other countries, is that there is a lack of efficient regulation and monitoring of pesticide use. In the last two decades, total pesticide consumption in Mexico has increased between 57% and 65%, with annual average annual differences of 27%, equivalent to 14,000 tonnes per year (MOO et al. 2020).

In Mexico, the institutions that regulate pesticides are SAGARPA and SSA. At the international level, the Food and Agriculture Organisation of the United Nations (FAO) has produced guidelines for pesticide management. They point out that the environment is one of the main sources of exposure to pesticides and their residues, as they come into contact with the environment, being susceptible to biological, chemical and physical degradation. However, direct exposure is the greatest risk, as chronic effects may manifest as cancer, mutations or degenerative lesions. In terms of production and consumption, SEMARNAT authorises the manufacture, importation, as well as activities related to pesticides, estimating that the average annual consumption in Mexico is 35 thousand tonnes from 1992 to 2007 (Ortíz et al., 2014).

Technologies in agriculture

Beltran (2022) states that platforms are digital tools that, when applied to the agricultural sector, increase competitiveness and production, favouring the development of agriculture as they have the potential to improve the yield and sustainability of crops, increasing the level of quality of products and processes, generating information at all times. The Internet of Things, agri-bots, data analytics, drones, cloud computing, the use of sensors and artificial intelligence are examples of the kind of applications that can be implemented in the agricultural sector. The challenges depend on the development and use of Information and Communication Technology (ICT)-based solutions as they have been recognised in smart and sustainable agriculture.

Information and communication systems have become a relevant tool for sustainability mainly in food systems and in the field; generating an environmental, social and economic impact on food distribution and consumption. The integration of Big Data and data analytics has been shown to improve agricultural productivity with good results, however, the sales margins of agricultural products can be a key factor. Information systems can facilitate the actual situation and logistics of transport, such as ways of selling, increasing productivity and profitability. There are positive impacts such as efficiency of natural resource use, increasing productivity and profitability, facilitating access to information and improving traceability of products (El Bilali, *et al*. 2018).

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Therefore, information systems can contribute to food sustainability, and agriculture is changing significantly with the integration of new technologies and devices for greater connectivity (Misra *et al*. 2020).

Unified Modelling Language

Munthe *et al*. (2020) describe UML (Unified Modelling Language) as a tool for modelling and designing information systems or applications. UML uses diagrams and text to describe a system. The modelling allows the design of useful applications, which must meet requirements and specifications. In this way, it is possible to evaluate the software project from its design. Once it has been approved by the evaluators, the information system software is controlled in an appropriate way through the developed prototype.

Databases and entity-relationship model

Millán (2017) states that the fundamentals of databases include definitions for manipulating data, whether structured and interrelated through a data model. These models are evaluated theoretically as well as practically by implementing them in applications. There are programming languages that allow manipulation of data, either to update it or to retrieve information from the database. These languages are declarative, thus reducing the development and maintenance time of applications. The relational model is defined as a set of relationships that changes over time, includes rules for inserting, updating or deleting, as well as relational algebra concepts. A query language is defined as a tool that uses expressions to make a request to the database.

Kofler (2004) describes a database as an ordered collection of data, which stores one or more files structured in cross-referenced tables in a relational model. Relational database management systems include MySQL, Oracle, Microsoft SQL Server and IBM DB2. These systems integrate security, storage, command processing for queries, data analysis and sorting. The database can be hosted on a computer or on a server. The program that connects to the database is defined as a database client.

Visual studio

Strauss & Strauss (2020) describe Visual Studio as a complete tool for developers, as it allows them to generate various types of applications in a productive way. Visual Studio has grown in recent years with a high power for software development worldwide. The latest versions are very similar so that it can be adapted to continuous development in later versions. It includes tools for pausing execution, as well as breakpoints for debugging errors and visualising results. In addition, it is possible to integrate projects with Git and GitHub in Visual Studio Code.

Methodology

Phase I. Capture of requirements: CATs must ensure the waste reduction procedure, where reception and weighing of packaging, sorting by type of material, compacting or shredding of packaging, as well as storage of bales, bags or sacks is carried out.

Phase II. Definition of processes for each type of system user. Figure 1 shows the diagram of the general use cases of the system.

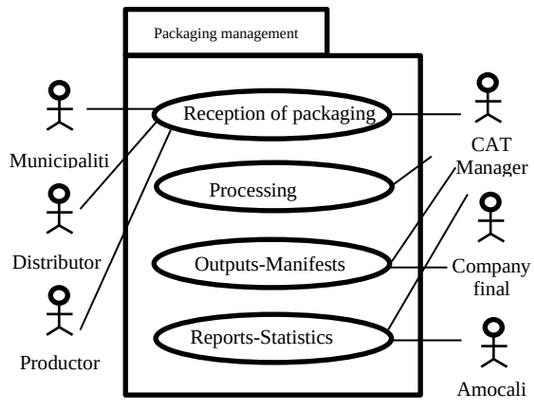

Figure 1 Diagram of general use cases of the packaging management system

Phase III. Design of the database in MySQL: The creation and design of the database was in MySQL locally, as no Internet access was available at the CATs, as they are distributed in remote regions. The application offers an option to download the database and later import it to a cloud server, thus allowing access to the information at the central offices.

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Phase IV. Coding: Creation of MySQL stored procedures for the generation of queries and implementation of reports, as well as the coding of logging options. The application code was created using Visual Studio 2023.

Phase V. Testing: Several unit tests and integration tests were carried out periodically, detecting defects that were immediately addressed.

Phase VI. Deployment: The application will be distributed in the CATs by zones in the state of Jalisco, selecting one in particular to carry out an initial pilot test. Users were trained in the use of the application. The implementation was straightforward, as no automated system was previously available.

Results

Forms were designed for capturing incoming containers, generating a record of origin, transport and containers received. At the end of the capture, a receipt of the received material is generated. See Figure 2 and Figure 3.

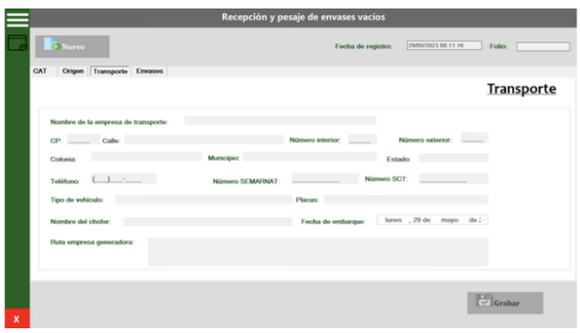

Figure 2 Capture of the origin reception of packaging

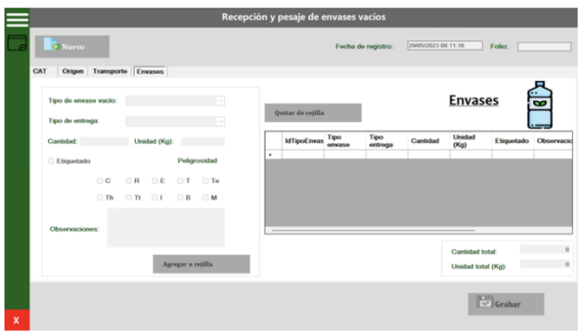

Figure 3 Capture of the type of packaging, hazardousness and weighing of the received packaging

Figure 4 shows an enquiry on the receipt of packaging by a distributor.

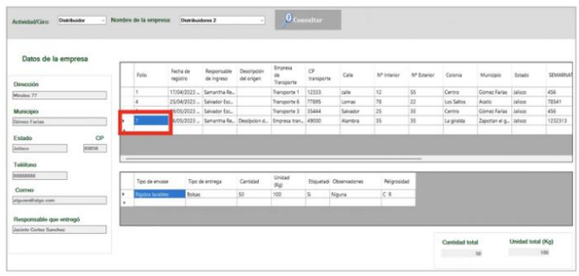

Figure 4 Enquiries on packaging received by distributor

Figure 5 shows the printout of the receipt representing proof of containers received by the CAT.

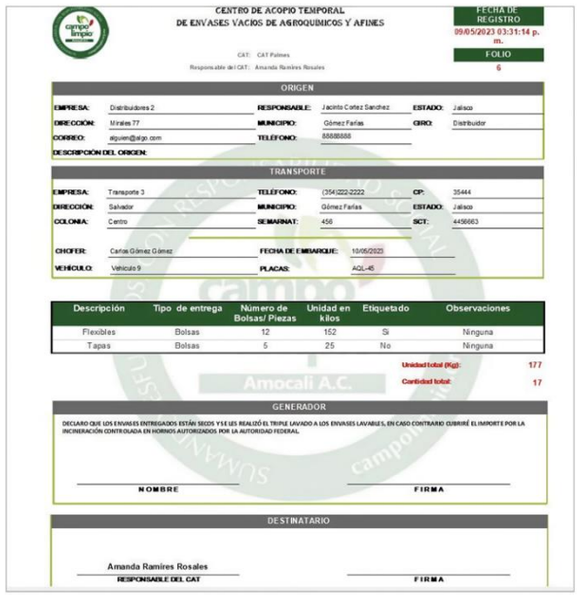

Figure 5 Printout of the receipt slip

Figure 6 shows the graph of the material sent and received in the destination companies, in the outgoing movements that occurred in a given period in the CAT.

Figure 6 Output of material sent and received in a period

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Figure 7 shows a report of containers received by type in a period. The type can be pails, flexible, metal, lids or drums.

Figure 7 Report of containers received by type in a period

Figure 8 shows a report of outlets in a period classified by type of material including a graph at the end of the report.

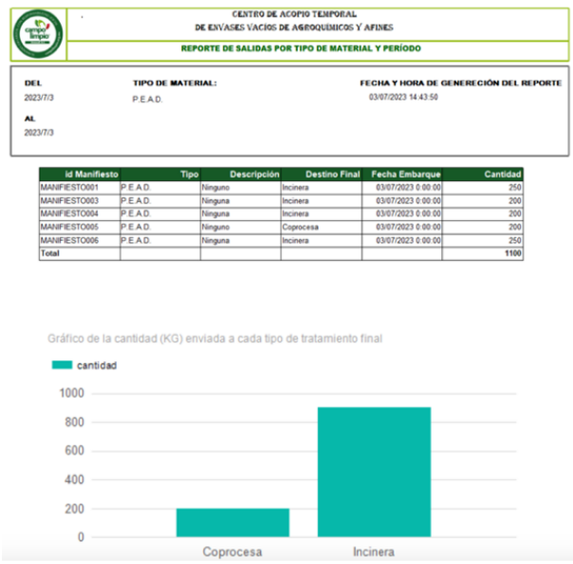

Figure 8 Report of outputs by type of material in a period.

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Conclusions

The development of the project allows for greater control in the administration of inventories within the CATs, generating valuable information in various formats, including receipts at reception as well as exit manifests for interested parties, generating various queries, reports and statistics. The CATs do not have a permanent internet connection, so the desktop application was developed with access to a local MySQL database, to be distributed and installed in each CAT, to be periodically exported and later imported to a cloud server. In this way, the central office will have permanent access to all the information, facilitating decision-making.

The management of agrochemical containers is of great importance, as it provides better inventory control and proper disposal. Some of the regulations and guidelines that support these practices are: hygiene, health and safety of workers, registration and documentation, inventory control, traceability records in packaging control and protection of chemicals and fertilisers. Therefore, it is of vital importance to ensure compliance with regulations and laws that guarantee the safety of people and the environment.

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