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E-Prediction of Water pH Meter Calibration Equipment Feasibility at Public Health Laboratory Using the Decision Tree Method

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Abstract*:Public Health Laboratories still commonly manage water pH meter calibration data manually using Microsoft Excel, which may cause calculation errors, data inconsistency, and inefficient evaluation. This study aims to develop a web-based E-Prediction system using the Decision Tree method to classify the feasibility of water pH meters.The study applied a quantitative approach based on the Knowledge Discovery in Databases (KDD) methodology. Calibration data were obtained from measurements using standard buffer solutions of pH 4, pH 7, and pH 10. The system calculated the absolute deviation between standard and measured values and classified the equipment as feasible when* $d \leq 0.02$*, requiring recalibration when* $0.02 < d < 0.05$*, and not feasible when* $d \geq 0.05$*pH units.The results show that the system successfully performed data input, deviation calculation, feasibility classification, data storage, and PDF report generation. The system improves the efficiency, consistency, transparency, and documentation of calibration-data management. However, the classification results represent agreement with predefined rules rather than independent predictive accuracy.*

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Introduction

Digital transformation has significantly influenced the public health sector, particularly in the implementation of information systems and data-driven technologies to improve operational efficiency, accuracy, and decision-making processes. In laboratory environments, the utilization of digital systems is increasingly important because laboratory services rely heavily on accurate data management and precise equipment calibration procedures. However, many Public Health Laboratories in Indonesia still manage calibration data manually using spreadsheet applications such as Microsoft Excel, resulting in inefficiencies, inconsistencies, and vulnerability to human error.

The Public Health Laboratory (LABKESMAS) plays a strategic role in ensuring environmental and public health quality through laboratory testing activities, including water quality examination. One of the most critical parameters in water quality testing is the pH level, which indicates the acidity or alkalinity of water. Accurate pH measurement is essential because inappropriate pH levels may negatively affect human health, water distribution systems, and environmental ecosystems. Therefore, the reliability and feasibility of water pH meters used in laboratory testing must always be maintained through regular calibration procedures.

Despite the importance of calibration activities, the management of pH meter calibration data at Public Health Laboratories is still commonly performed manually. Calibration officers generally evaluate equipment feasibility by calculating deviations between standard buffer values and measured values using Microsoft Excel. This conventional process creates several problems, including slow data processing, difficulties in historical data tracking, inconsistency in evaluation results, and the risk of calculation errors. Furthermore, manual assessment methods often rely on subjective technician interpretation rather than structured analytical approaches.

The limitations of manual calibration management demonstrate the urgent need for a more systematic and automated approach to evaluating laboratory equipment feasibility. In this context, data mining methods, particularly the Decision Tree algorithm, provide an effective solution for analyzing calibration data and generating objective feasibility classifications.

The Decision Tree method is widely recognized for its simplicity, transparency, and ability to produce interpretable decision rules in the form of if–then logic. These characteristics make the algorithm highly suitable for laboratory decision support systems where transparency and consistency are required.

Several previous studies have demonstrated the effectiveness of Decision Tree algorithms in environmental and healthcare data analysis. Decision Tree has been successfully applied in water quality classification systems, environmental monitoring, and healthcare decision support applications. However, most previous studies focused primarily on water quality analysis rather than evaluating the feasibility of laboratory measuring instruments such as water pH meters. In addition, prior studies rarely integrated historical calibration data into a web-based prediction system capable of automatically classifying equipment feasibility.

This research attempts to address these limitations through the development of a web-based E-Prediction System for Water pH Meter Calibration Equipment Feasibility using the Decision Tree method. The proposed system is designed to process historical and real-time calibration data based on standard buffer parameters pH 4, pH 7, and pH 10. The classification mechanism utilizes deviation threshold rules embedded within the Decision Tree structure to classify equipment into feasible, requiring recalibration, or unfeasible categories.

Furthermore, this study not only focuses on the technical implementation of the Decision Tree algorithm but also emphasizes its practical contribution to laboratory operational

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efficiency. The developed system provides centralized calibration data management, automatic feasibility classification, PDF-based report generation, and transparent decision-making support for calibration officers and technical laboratory managers.

Based on this background, the research problems formulated in this study are as follows:

1. How can historical and real-time calibration data of water pH meters be prepared and processed for the implementation of the Decision Tree algorithm?
2. How can a web-based E-Prediction system be designed and developed to implement the Decision Tree algorithm for determining the feasibility of water pH meter calibration equipment?
3. How effective is the Decision Tree algorithm in classifying the feasibility status of water pH meter equipment based on calibration deviation values?

Research Methods

Based on observations conducted at the Public Health Laboratory (LABKESMAS), the management of water pH meter calibration data is still performed using conventional methods through manual calculations and simple Microsoft Excel spreadsheets. Calibration data are generally stored only as administrative records and are not optimally utilized as a source of analytical information for systematic decision-making. Consequently, the historical calibration data have not contributed effectively to supporting objective equipment feasibility evaluation processes. In addition, the manual calibration system presents several operational problems, including slow data processing, difficulties in tracking historical calibration records, inconsistent evaluation results, and a high risk of human error in deviation calculations.

These limitations indicate the necessity for a computerized and web-based system capable of processing calibration data automatically and systematically. Therefore, this research proposes the development of a web-based E-Prediction system that implements the Decision Tree algorithm to determine the feasibility status of water pH meter calibration equipment. The developed system is expected to improve efficiency, consistency, transparency, and accuracy in laboratory equipment evaluation procedures.

This study applies a quantitative research approach combined with data mining techniques using the Knowledge Discovery in Database (KDD) methodology. The KDD stages implemented in this research consist of data collection, data preprocessing, data transformation, Decision Tree implementation, and interpretation of classification results. The dataset used in this study consists of historical calibration data and newly input calibration records of water pH meters at the Public Health Laboratory.

The calibration process uses three standard buffer parameters, namely pH 4, pH 7, and pH 10. Each calibration record contains information regarding standard buffer values, measured values, deviation calculations, calibration dates, and equipment feasibility status. During the preprocessing stage, several activities are performed, including data cleaning, validation of calibration input values, and calculation of deviation values between standard and measured pH values. This process aims to ensure that the dataset used for classification is accurate, complete, and consistent.

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The Decision Tree algorithm is then applied to classify the feasibility status of the calibration equipment based on predefined deviation threshold rules. The classification process uses if–then logical rules embedded within the decision tree structure. Equipment with deviation values less than or equal to 0.02 pH is classified as feasible, deviation values greater than 0.02 pH and less than 0.05 pH are categorized as requiring recalibration, and deviation values greater than or equal to 0.05 pH are classified as unfeasible.

The system development process also includes database design, user interface implementation, and report generation features. The web-based system is developed using Laravel 11 as the application framework, PHP as the programming language, MySQL as the database management system, and Visual Studio Code as the development environment. In addition, Unified Modeling Language (UML) diagrams such as Use Case Diagrams, Activity Diagrams, Sequence Diagrams, and Class Diagrams are utilized to model the system structure and workflow.

The classification results generated by the Decision Tree algorithm are displayed through an interactive web interface and stored automatically in the database. The system also provides automatic PDF-based report generation to support laboratory documentation and administrative activities. Thus, the proposed system not only improves calibration data processing efficiency but also assists laboratory officers in performing faster, more objective, and data-driven equipment feasibility evaluations.

Results and Discussion

System Requirements

This section describes the hardware and software specifications used in developing and operating the web-based E-Prediction system for determining the feasibility of water pH meter calibration equipment using the Decision Tree algorithm. The system environment consists of hardware and software components that support calibration data processing, Decision Tree classification, database management, and web-based system implementation.

1. **Hardware Requirements**

The hardware specifications required to develop and operate the system are as follows:

a. Processor : The system requires a minimum Intel Core i3 8th Generation processor or equivalent specifications. This processor capability is sufficient to support calibration data processing, Decision Tree classification, database operations, and web-based application execution efficiently.

b. Random Access Memory (RAM) : A minimum of 8 GB RAM is required to ensure smooth system performance during calibration data input, classification processing, report generation, and database management activities.

c. Storage : The development and operational environment uses at least a 256 GB Solid State Drive (SSD). SSD technology accelerates operating system performance, application loading,

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database access, and report generation processes.
d. Network Connection : A stable internet or local network connection is necessary to support web-based system access, especially during multi-user laboratory operations and data synchronization activities.

2. Software Requirements

The The software used in the development of the E-Prediction system includes the following components:
a. Operating System : The system can operate on Windows 10/11 operating systems. The operating system functions as the primary platform for application development and deployment.
b. Programming Language : The system is developed using PHP programming language integrated with the Laravel 11 framework. According to Fikri (2025), Laravel is widely used in web-based information system development because it provides structured coding architecture, security features, and efficient database integration. PHP was selected because it supports dynamic web application development and simplifies server-side processing.
c. Integrated Development Environment (IDE) : Visual Studio Code is utilized as the primary code editor during system development. Microsoft (2023) explained that Visual Studio Code provides efficient programming tools, debugging features, and extension support that facilitate modern software development processes.
d. Database Management System : The system uses MySQL as the database management system to store calibration records, user data, classification results, and report information. According to Indra (2025), MySQL is highly suitable for web-based applications because it provides efficient data storage, fast query processing, and stable multi-user database management capabilities.
e. Local Server : XAMPP is used as the local server environment during development and testing processes. Apache Friends (2023) stated that XAMPP simplifies local web server configuration by integrating Apache, PHP, and MySQL within a single development environment.

System Implementation

System System implementation is the stage of transforming the system design into a web-based E-Prediction application for determining the feasibility of water pH meter calibration equipment at the Public Health Laboratory (LABKESMAS). The system was developed using Laravel 11, PHP, and MySQL to support calibration data processing, database management, and automatic classification using the Decision Tree algorithm.

The implementation includes user login features, calibration data input, automatic deviation calculation, feasibility classification, historical data storage, and PDF report generation. Based on predefined deviation rules, the system classifies equipment into feasible, requiring recalibration, or unfeasible categories.

According to Qisthiano (2023), the Decision Tree method is effective for classification systems because it produces transparent and easy-to-understand decision rules. Overall, the developed system improves operational efficiency, reduces manual calculation errors, and supports faster and more objective laboratory equipment feasibility evaluations.

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1) **System Interface Implementation**

a. **Admin Login Page:** The Admin Login Page is used by laboratory administrators or calibration officers to access the web-based E-Prediction system. On this page, users are required to enter a registered username and password correctly. The authentication process ensures that only authorized users can access the system. If the entered credentials are valid, the user will be redirected to the dashboard page. However, if the username or password is incorrect, the system will display an error notification message indicating invalid login data.

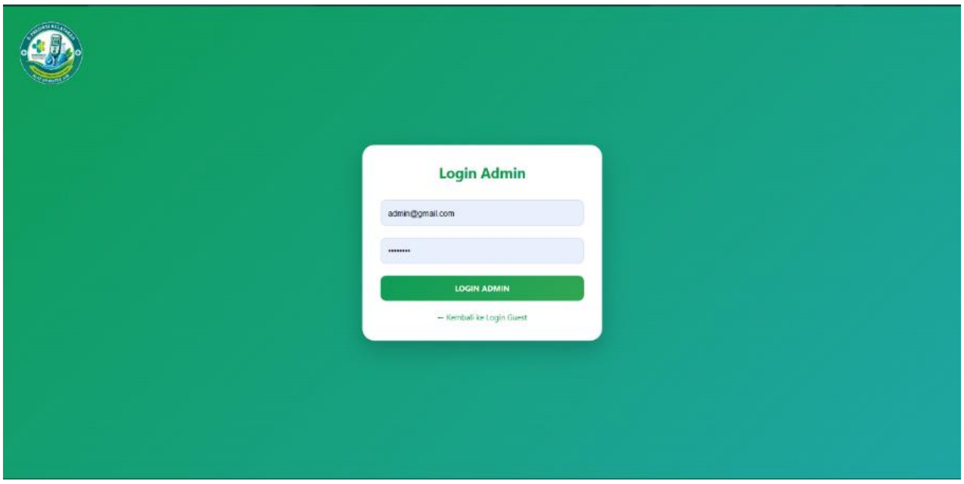

Figure 1 Admin Login Page View

b. **Dashboard Page :** The Dashboard Page is the main interface displayed after the administrator or laboratory officer successfully logs into the E-Prediction system. This page functions as the central navigation area for accessing all system features, such as calibration data input, feasibility classification results, historical calibration data, and PDF report generation. The dashboard also displays summary information related to calibration activities, including the total number of calibration data records, equipment feasibility status, recent calibration results, and navigation menus for managing calibration data and prediction processes.

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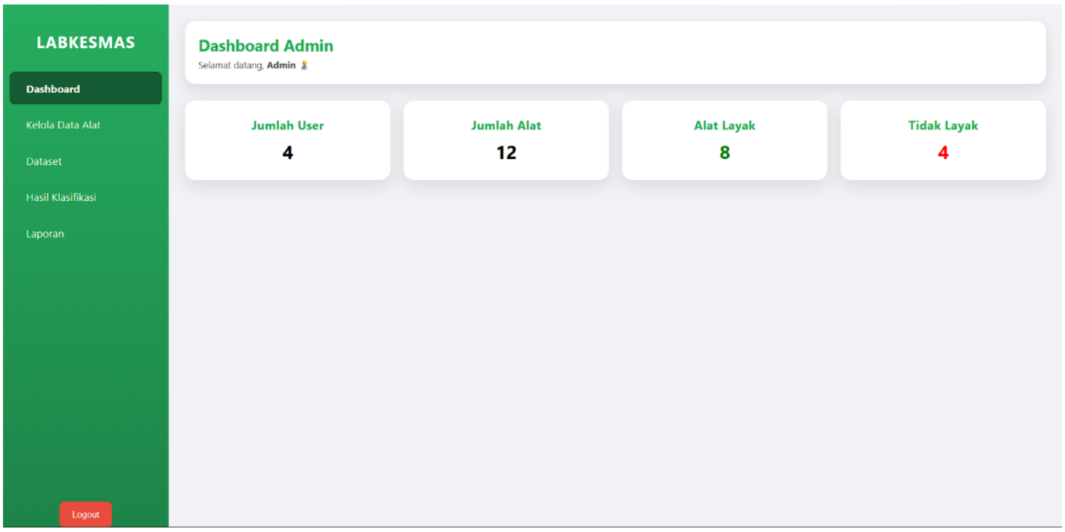

Figure 1 Dashboard Page

c. **Data Input Page:** The Data Input Page is used to collect administrative and technical calibration data before the classification process is performed. The form includes equipment information such as device brand, serial number, equipment owner, examiner name, and pH buffer values (4, 7, and 10). Before the data are stored in the database, the system performs input validation to ensure that all required fields are completed correctly. The inspection date is filled automatically based on the current date to reduce human error. After the user clicks the "SAVE" button, the numerical calibration data are processed as input for the Decision Tree classification system. This page helps maintain data consistency and supports accurate equipment feasibility evaluation.

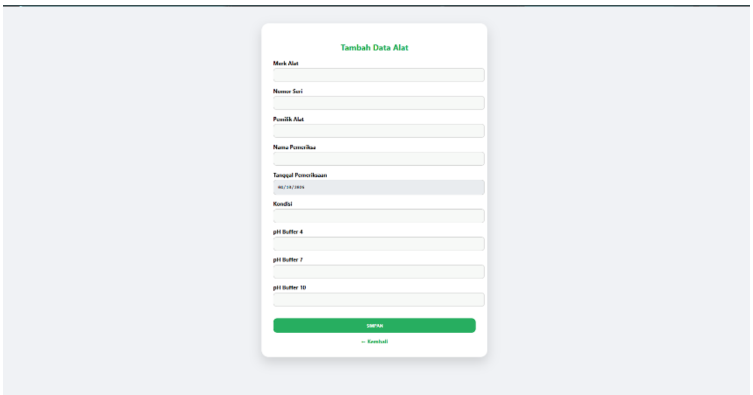

Figure 2 Data Input Page

d. **Classification Results Page:** Clustering The Classification Results Page displays the output generated by the Decision Tree algorithm based on calibration data input. The system automatically determines the feasibility status of the water pH meter equipment. This page shows summary statistics, classification charts, and detailed tables containing equipment information, inspection dates, and feasibility status. The system also provides search and filter features, while all classification results are stored automatically in the database for monitoring and reporting purposes.

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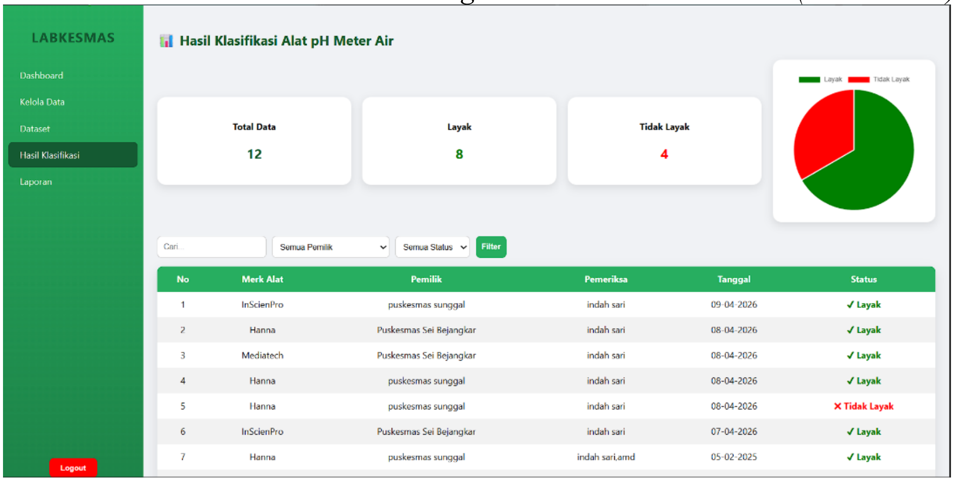

Figure 3 Classification Results Page

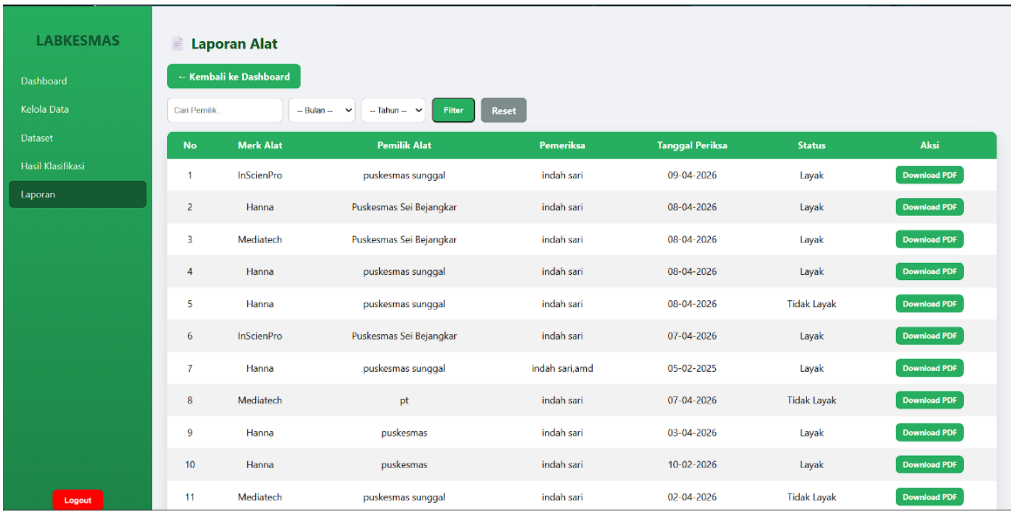

Figure 4 Water pH meter Report Page

2) Implementation of Data Processing Module and Decision Tree Algorithm

This This module is the core component of the E-Prediction system that implements the Decision Tree classification process described in Chapter III.

a. Data Input Module : This module functions to receive and store calibration data input, including pH buffer values (4, 7, and 10), equipment information, and inspection data.
b. Data Preprocessing Module : This module performs data validation, data cleaning, and deviation calculations between measured values and standard buffer values to ensure data

consistency and accuracy before classification.
c. Decision Tree Classification Module : This module implements the Decision Tree algorithm to classify the feasibility status of water pH meter equipment automatically. According to Qisthiano (2023), the Decision Tree method is effective for prediction and classification systems because it produces simple and transparent decision rules. The classification process uses predefined deviation thresholds to determine whether the equipment is feasible, requires recalibration, or is unfeasible.

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d. Output Module : This module displays classification results in the form of summary statistics, charts, and detailed tables containing equipment information and feasibility status. The results are also stored automatically in the database for monitoring and reporting purposes.

System Testing

System testing was conducted to ensure that all system functions operated according to functional requirements. The testing process included login testing, calibration data input testing, Decision Tree classification testing, and report generation testing. The results showed that the system successfully processed calibration data accurately and generated automatic feasibility classifications effectively.

1. **Functionality Testing**

The System testing in this research was conducted using the Black Box Testing method to ensure that every system feature operated according to the specified requirements without examining the program source code. The testing process included:

a. Admin Login Testing : Ensuring that only authorized administrators or laboratory officers can access the system using valid login credentials.

b. Calibration Data Input Testing : Verifying that the system can receive, validate, and store calibration data correctly.

c. Data Processing Testing : Ensuring that deviation calculations and data validation processes operate accurately before classification.

d. Decision Tree Classification Testing : Verifying that the Decision Tree algorithm correctly classifies equipment into feasible, requiring recalibration, or unfeasible categories. According to Qisthiano (2023), Decision Tree is effective for classification systems because it produces accurate and transparent decision rules.

e. Results Display Testing : Ensuring that classification results, charts, tables, and PDF reports are displayed correctly and informatively.

The testing results showed that all system features functioned properly and supported accurate and efficient laboratory equipment feasibility evaluation processes.

2. **Accuracy Testing and Clustering Validation**

This Accuracy testing was conducted to evaluate the effectiveness of the Decision Tree algorithm in classifying the feasibility status of water pH meter calibration equipment.

a. Classification Accuracy Testing : The classification results generated by the system were compared with manual calculations performed using Microsoft Excel. The results showed that the system produced accurate and consistent classifications based on predefined deviation threshold rules.

b. Decision Rule Validation : The Decision Tree classification rules were validated to ensure that the generated feasibility status matched laboratory calibration standards. According to Qisthiano (2023), Decision Tree algorithms provide transparent and interpretable classification results through if–then decision rules.

c. System Performance Validation : The system was tested to ensure that calibration data processing, automatic classification, and report generation operated correctly without errors.

d. Data Consistency Validation : Validation was also conducted to ensure that calibration data stored in the database remained consistent and could be retrieved properly for monitoring and

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reporting purposes.
The testing results demonstrated that the developed E-Prediction system successfully supported accurate, efficient, and data-driven laboratory equipment feasibility evaluation processes.

Analysis and Interpretation of Results

The implementation of the Decision Tree algorithm successfully classified the feasibility status of water pH meter calibration equipment based on deviation values obtained from calibration measurements. The classification results provide an effective and transparent approach for supporting laboratory equipment evaluation processes at the Public Health Laboratory (LABKESMAS).

Based on the classification process, the system divides equipment feasibility into three main categories: feasible, requiring recalibration, and unfeasible.

1. **Feasible Equipment Classification**

Equipment classified as feasible has deviation values less than or equal to 0.02 pH. This indicates that the calibration results are still within acceptable laboratory standards and the equipment can be used properly for water quality testing activities. These results show that the equipment maintains good measurement accuracy and does not require additional calibration procedures.

2. **Recalibration Classification**

Equipment classified as requiring recalibration has deviation values greater than 0.02 pH and less than 0.05 pH. This category indicates that the equipment accuracy has slightly decreased and recalibration is recommended to maintain measurement reliability. The system helps laboratory officers identify equipment that requires preventive maintenance before reaching an unfeasible condition.

3. **Unfeasible Equipment Classification**

The Equipment classified as unfeasible has deviation values greater than or equal to 0.05 pH. This indicates that the calibration results exceed acceptable tolerance limits and the equipment should not be used for laboratory testing activities. According to Qisthiano (2023), the Decision Tree method is effective because it produces transparent and easy-to-understand classification rules. The implementation results demonstrate that the developed system successfully transforms calibration data into objective and data-driven feasibility information for laboratory monitoring and decision-making processes.illnesses.

System Advantages

The developed E-Prediction system provides several advantages in supporting the feasibility evaluation process of water pH meter calibration equipment at the Public Health

Laboratory (LABKESMAS). The main advantage of the system is its ability to automatically process calibration data and classify equipment feasibility using the Decision Tree algorithm.
The system integrates calibration data input, deviation calculation, classification processing, historical data storage, and PDF report generation into a single web-based platform. According to Ricky (2024), web-based information systems improve operational efficiency and simplify data management processes. Another advantage is the automatic classification feature that helps laboratory officers reduce manual calculation errors and improve decision-making consistency.

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According to Qisthiano (2023), the Decision Tree method is effective because it produces transparent and easy-to-understand decision rules.

The system also provides visualization features such as charts, summary statistics, and detailed classification tables, making the analysis results easier to understand. In addition, the implemented interface is simple and user-friendly, allowing laboratory personnel to operate the system efficiently without requiring advanced technical expertise.

System Deficiencies

Although the developed E-Prediction system has operated effectively, several limitations were identified during implementation and testing. One limitation is that the system only uses the Decision Tree algorithm without comparison to other classification methods that may provide different prediction results. In addition, the system highly depends on the accuracy of calibration data entered by users. Incorrect or incomplete calibration input may affect the classification results generated by the system. Therefore, careful data validation is still required during the calibration input process.

Another limitation is that the system currently supports only administrator or laboratory officer access and does not yet provide multi-user role management features. Furthermore, the visualization features available in the system are still relatively simple and limited to basic charts and tables. According to Ricky (2024), web-based systems require continuous development to improve functionality, flexibility, and user interaction. Therefore, further system development is necessary to enhance visualization features, multi-user access management, and overall system capabilities.

Conclusion and Recommendation

Based on the research results, it can be concluded that the implementation of the Decision Tree algorithm in the web-based E-Prediction system successfully supports the feasibility evaluation process of water pH meter calibration equipment at the Public Health Laboratory (LABKESMAS). The developed system is capable of processing calibration data automatically, calculating deviation values, and classifying equipment into feasible, requiring recalibration, and unfeasible categories based on predefined laboratory standards. The implementation results indicate that the system improves operational efficiency, reduces manual calculation errors, and supports faster and more objective decision-making processes. According to Qisthiano (2023), the Decision Tree method is effective because it produces transparent and easy-to-understand classification rules.

Based on the research findings, it is recommended that the Public Health Laboratory continue utilizing the E-Prediction system to support calibration data management and laboratory equipment monitoring activities. Future system development may include the implementation of additional classification methods, more interactive visualization features, and multi-user access management to improve overall system functionality and flexibility.

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