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The Analysis of Occupational Safety and Health of the Batik Industry

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Abstract. Occupational safety and health is an important issue in an operational process, both in traditional and modern sectors. Prevention of work accidents can be done by knowing the risks that exist in a process, one of them is through Hazard Identification, Risk Assessment, and Risk Control (HIRARC) methods. In the batik industry, batik makers come into direct contact with materials containing hazardous chemicals and uncomfortable work positions. In addition, the craftsmen also do not care for the environment and do not use personal protective equipment. The purpose of this study is to determine the factors of occupational safety and health. This purpose also to use of personal protective equipment while working and identify potential hazards in the batik production process in the batik industry of Sekar Arum and Mahkota Laweyan. Factors causing occupational accidents include an unsafe batik environment, unsafe equipment, containing hazardous substances and unsafe work attitudes. In addition, the lack of orderly use of personal protective equipment in the form of boots, gloves and aprons. Based on the findings of the hazard, it is known that there are hazards with low category namely in the *nyanting* room, washing and drying rooms, and the waste management room with hazard percentage is 10,26 %, medium category namely in the stamp room with hazard percentage is 30,77 % and high category namely the coloring room with hazard percentage is 38,46 %.

Keywords: Personal Protective Equipment; HIRARC; Occupational Safety and Health

1. Introduction

The batik industry an important role in national economic growth. The sector, which is dominated by small and medium industries, is able to contribute significantly to the country's foreign exchange from exports. According to the ministry of industry, the export value of batik and batik products until October 2017 reached USD 51.15 Million. Along with the increasing demand for batik and batik products, the batik industry is demanded to increase its productivity in order to meet the demand with good quality.

Surakarta is one of the batik producing cities in Indonesia. One of the places that can be visited is Batik Sekar Arum and Mahkota Laweyan in Laweyan Village, Surakarta. In this place there are several batik making processes that take place, namely the process of cutting cloth, stamp, coloring, drying, and arranging batik cloth. The process is almost entirely done manually. Because it is done manually, humans have a very important role in the sustainability of the production process. But humans have limitations, so in carrying out their work humans can make mistakes. And the lack of

human awareness on occupational safety and health so that the potential to cause accidents due to work.

Occupational safety and health an attempt and thought to guarantee the integrity and perfection of both physical as well as spiritual human beings in general and of labor in particular, along wiht the result of his work in the community toward a just, prosperous and peace [1]. How to cope with work accidents is by eliminating the elements causing the accident or holding strict supervision. In batik industry Sekar Arum and Mahkota Laweyan there are several types of chemicals that have the potential to cause occupational hazards and accidents, most workers do not use any personal protection so they come into direct contact with these chemicals. Therefore, workers must know the hazards they face while working and can prevent them.

The final goal to be achieved in this study is to determine the factors of occupational safety and health and the use of personal protective equipment when working together to identify potential hazards in the batik production process in the batik industry of Sekar Arum and Mahkota Laweyan.

2. Methods

This research was carried out in the batik industry of Sekar Arum and Mahkota Laweyan in Laweyan village, Surakarta. This research began in September - November 2019. Data collection was carried out by direct observation in the production area, interviews with workers and literature study.

This research uses the HIRARC method. Process of HIRARC requires 4 simple steps, there are classify work activities, identify hazard, conduct risk assessment and decide if risk is tolerable and apply control measures [2]. The first step in research is classify work activites. This step is classify geographical or physical area include outside premises, stages in production or service process and defined task of work. Next step is identify hazard. This is process of examining each work area and task for purpose of identifying all the hazards which are inherent in the job. The next step is risk assessment. Risk assessment is process of evaluating the risks to safety and health arising from hazards at work. The purpose of the risk assessment process is to remove a hazard or reduce the level of its risk by adding precautions or control measures, as necessary. For risk analysis that uses likelihood and severity in qualitative method, presenting result in a risk matrix is a very effective way of communicating the distribution of the risk throughout a plant and area in a workplace [3]. In mathematical term, risk can be calculated by the equation :

$$\text{Risk (R)} = \text{Likelihood (L)} \times \text{Severity (S)} \quad (1)$$

Here is the table of likelihood and severity of the risk :

Table 1. Likelihood Value

Likelihood (L)	Example	Rating
Most likely	The most likely result of the hazard / event being realized	5
Possible	Has a good chance of occurring and is not unusual	4
Conceivable	Might be occur at sometime in future	3
Remote	Has not been known to occur after many years	2
Inconceivable	Is practically impossible and has never occurred	1

Table 2. Severity Value

Saverity (S)	Example	Rating
Catastrophic	Numerous fatalities, irrecoverable property damage and productivity	5
Fatal	Approximately one single fatality major property damage if	4

	hazard is realized	
Serious	Non-fatal injury, permanent disability	3
Minor	Disabling but not permanent injury	2
Negligible	Minor abrasions, bruises, cuts, first aid type injury	1

Based on table 1 and table 2, can determining the level of risk. This to find out any risk that requires immediate treatment based on the risk assessment. this determination was based on the risk assessment matrix is devided into 3 categories, there are low risk, medium risk and high risk. here is the matrix of risk assessment. Here is the matrix of risk assessment at Table 3.

Table 3. Matrix of Risk Assessment

Likelihood (L)	Saverity (S)				
	1 Negligible	2 Minor	3 Serious	4 Fatal	5 Catastrophic
5 Most likely	5	10	15	20	25
4 Possible	4	8	12	16	20
3 Conceivable	3	6	9	12	15
2 Remote	2	4	6	8	10
1 Inconceivable	1	2	3	4	5

= High = Medium = Low

The relative risk value can be used to prioritize necessary actions to effectively managework place hazards. Table 4 determines priority based on the following ranges:

Table 4. Level of Risk

Risk	Description	Action
15-25	High	A HIGH risk requires immediate action to control the hazard as detailed in the hierarchy of control. Actions taken must be documented on the risk assessment form including date for completion.
5-12	Medium	A MEDIUM risk requires a planned approach to controlling the hazard and applies temporary measure if required. Actions taken must be documented on the risk assessment form including date for completion.
1-4	Low	A risk identified as LOW may be considered as acceptable and further reduction may not be necessary. However, if the risk can be resolved quickly and efficiently, control measures should be implemented and recorded.

3. Results and discussion

The work accident that was experienced by the batik industry of Sekar Arum and Mahkota Laweyan was a fire. The fire that occurred was caused by a candle heating stove. Based on interviews with workers it is known that workers already understand how to extinguish the fire.

The Sekar Arum and Mahkota Laweyan batik industries have never done disaster management simulations to their workers. So that workers do not yet have the provision of knowledge in case of disasters such as severe fires, earthquakes, explosions and other disasters. In addition, the two industries have not yet carried out regular health checks on their workers. So the health impacts arising from work cannot be measured and the health of workers is also not guaranteed.

The following is Hazard's findings in the batik making area, as in Table 5 .

Table 5. Hazard in Batik Industry Area

Location	Hazard's Finding	Risk	Risk Analysis				
			L	S	R	Category	Hazard Percentage
Nyanting Room	Workers exposed to hot candles and candle steam	Redness of the skin when exposed to hot candles and dizziness and shortness of breath if hot candle steam is inhaled	4	1	4	Low	10,26 %
Coloring Room	Workers exposed to coloring agents (naphthol) and NaOH, $NaNO_2$	If exposed to the skin can cause skin irritation to festering. If inhaled will cause dizziness and shortness of breath. And can cause slipping.	5	3	15	High	38,46 %
Washing and Drying Room	Pekerja terkena zat pewarna (naftol) dan NaOH, $NaNO_2$	If exposed to the skin can cause skin irritation. If not careful can slip	4	1	4	Low	10,26 %
Waste Management Room	Workers exposed to heating flames, hot candle steam, and puddles of waste water	There is a fire and can slip	4	1	4	Low	10,26 %
Stamp Room	Workers exposed to hot candles and candle	Redness of the skin when exposed to hot candles and dizziness and	4	3	12	Medium	30,77 %

	steam	shortness of breath if hot candle steam is inhaled

From the findings of the hazard it is known that there are hazards with low category namely in the nyanting room, washing and drying rooms, and the waste management room with hazard percentage is 10,26 %, medium category namely in the stamp room with hazard percentage is 30,77% and high category namely the coloring room with hazard percentage is 38,46%. The following is a hazard level column chart presented in Figure 1 below:

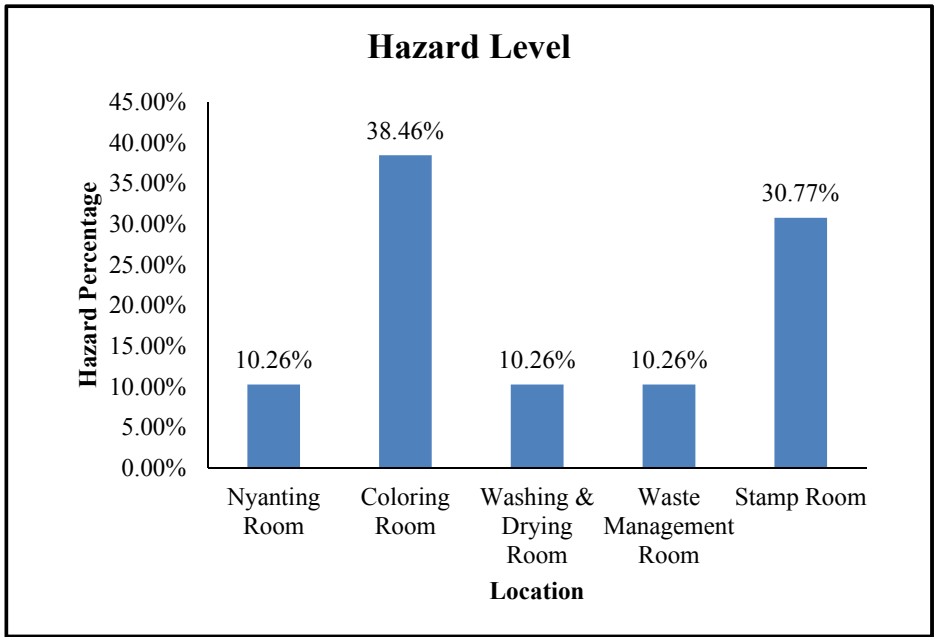

Figure 1. Hazard Column Chart

The identification of hazards and risk in the batik industry of Sekar Arum and Mahkota Laweyan can be explaind in detail about the deviations that might occur in Table 6.

Table 6. Identification of hazards and risks in the batik industry

Process	Deviation	Consequences	Cause	Suggested action
Batik or *Nyanting*	Workers do not use masks and gloves	Exposure to hot steam inhalation and burns if exposed to hot candles.	Personal Protective Equipment is available but workers do not use it and workers do not understand the hazards of chemicals to the body	Make visual displays so workers understand the hazards of candle candles and their mixtures.
Coloring	Workers do not use a personal protective	Exposure to inhaled dyes. Skin irritation due to	Workers do not understand the hazard of coloring substances	Provides adequate personal protective equipment and

	equipment	body exposure to dyes. Slipping if exposed to dye splashes	(naphthol) for the body and the environment	makes a visual display and provides a shelter for dyes (naphthol)
Washing and Drying	Do not wear gloves and footwear, the dye is not managed properly	Skin irritation due to body exposure to dyes. Slipping if exposed to dyes and washing water	Workers do not understand the hazard of coloring substances (naphthol) for the body and the environment	Provides personal protective equipment and makes a visual display so workers understand work safety
Waste treatment	Do not wear gloves and footwear, waste is not managed properly	Skin irritation due to body exposure to dyes. Slipping if exposed to dyes and washing water	Workers do not understand the hazard of coloring substances (naphthol) for the body and the environment	Provide personal protective equipmwnt and make a visual display so that workers understand the safety of work and waste storage
Stamp	Not wearing adequate heat and body protection gloves	Exposure to hot steam inhalation and burns if exposed to hot candles	Workers do not understand the hazard of coloring substances (naphthol) for the body and the environment	Provides personal protective equipment and makes a visual display so workers understand work safety

Based on the data obtained then analyzed based on direct observations, interviews, and evaluation of potential hazards, recommendations for occupational safety and health standards for the Sekar Arum and Mahkota Laweyan batik industry are given as follows, the layout of the factory is made with the appropriate distance between the combustion tool, fuel and fabric production. Install an alarm as an information system. This alarm is useful as a sign or warning that a disaster has occurred so that the owner or worker can save themselves and overcome the disaster.Conducting activities that maintain and empower the quality of a good work environment, such as cleaning the entire factory and surroundings. Repairing equipment that is not feasible to use as well as making adequate waste disposal channels so as not to be scattered on the floor. Procurement of personal protective equipment and checking the availability of PPE periodically. Conducting inspection and evaluating the feasibility of the factory where it works as well as knowing the discipline of workers at work and in the use of personal protective equipment that supports while working. Conduct regular health checks for workers to be able to monitor the condition of workers or occupational diseases.

4. Conclusion

Factors causing occupational accidents include an unsafe batik environment, unsafe equipment, dyes containing hazardous substances and unsafe work attitudes. In addition, the lack of orderly use of Personal Protective Equipment in the form of boots, gloves and aprons . Based on the findings of the hazard, it is known that there are hazards with low category namely in the nyanting room, washing and drying rooms, and the waste management room with hazard percentage is 10,26 %, medium category namely in the stamp room with hazard percentage is 30,77 % and high category namely the Coloring room with hazard percentage is 38,46 %. Suggested improvement is to conduct training and counseling to workers in the Sekar Arum and Mahkota Laweyan batik industry on occupational safety and health on a regular basis. This training is expected to increase workers awareness of occupational

safety and health hazards and use of personal protective equipment while working. In addition, as soon as possible to control the potential sources of hazards and take action to control the risk of work accidents. And increasing the number of available personal protection equipment that meets the standards, so that enough for workers. The owner of the batik industry must carry out regular supervision of workers in using personal protection equipment.

Acknowledgements
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The Application of Mahagony Bark (*Swietenia Mahagony L.*) for Natural Dyeing

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Abstract. Recently many batik industries owner have switched to using natural dyes because synthetic dyes in the long time have a negative impact on the environment. Natural dyes that are widely used are mahogany (*Swietenia Mahagony L.*) bark dyes. In the process of coloring batik fabric, there is stage of fixation. Fixation is the stage of binding the color with the fixator. There are three types of fixators used, namely alum ($Al_2(SO_4)_3.12H_2O$), calcium oxide (CaO) and ferrous sulphate ($FeSO_4$) with certain concentrations. The owner of batik industries don't know yet the concentration of a strong and optimal fixator for binding natural dyes in batik fabric. The purpose of this study is to determine the type of strong fixator and optimal concentration of fixator for binding natural mahogany dyes on batik fabric. The owner of batik industries usually use an estimated concentration of 30 g / L to 100 g / L. In this study, the variables are 30 g / L, 60 g / L and 90 g / L in each type of fixator to test the color aging value. and color fastness to rub wet and dry. Judging from the value of R% (color aging) and color fastness test against wet and dry rubbing, it can be concluded that alum and calcium oxide are strong fixators that used with mahogany dyes and the most optimal concentration of alum and calcium oxide is 60 g / L.

Keywords: natural dye; mahagony bark; fixator; batik fabric

1. Introduction

According to Shawabkeh RA, & Tutunji MF, 2003 [1] the use of synthetic dyes can cause environmental pollution and is a hazardous material, because some dyes can be degraded into carcinogenic and toxic compounds. Full-color textile industry waste and organic chemicals from synthetic dyes. According to Kant.R, 2012 [2] mixing colloidal material with dye waste, can increase turbidity and make water look bad, smell, prevent sunlight penetration. The impact is the depletion of dissolved oxygen, decreased water quality and the death of living things that live in it due to lack of oxygen or contaminated with toxic compounds. Besides that when the waste is allowed to flow it will clog the pores of the soil resulting in loss of soil productivity, soil texture harden and prevent penetration of plant roots.

In this study mahogany bark was used. Mahogany bark is not only used by batik artisans in the Boyolali area. According to Indrianingsih, A.W., et al, 2013 [3] The batik industries owner in the city of Probolinggo also use mahogany bark as their batik coloring. The extraction of mahogany bark produce brownish red-brown color. The extract of Mahogany tree bark can be used to color the wood, Boo E, 1990 [4]. The extract is also used as a dye in the leather tanning process.

The uses of mahogany as natural dye were common among society in developing countries. Bangladeshi society accustomed to using the extraction of mahogany tree bark as a natural dye for

textiles,Lascurian C, 1996 [5]. The disadvantage of natural dyes is lower fade resistance than synthetic dyes. To obtain high fastness is needed a process of fixation (color generation) which aims to sharpen the color and so it does not fade easily. So far, the batik industries owner who use natural dyes still do not know the exact size of the fixator and the best type of fixator to generate the color of the natural dye.

Based on the description, the research was carried out in the form of a dye binding business using fixation materials such as alum, calcium oxide, and ferrous sulphate with concentrations of 30 g / L, 60 g / L and 90 g / L. The selection of fixation materials is based on the nature of substances that are relatively harmless to the environment. As a natural coloring agent, mahogany bark is extracted for 1 hour using a water solvent. In this research, the quality of natural dyes produced was tested for quality, namely the value of color fastness to rubbing wet and dry fabric and color aging test.

2. Methods

2.1. Materials

In this study using various materials. The most important ingredients are mori premisima fabric and natural mahogany bark extract which has been extracted. The next material is fixator consisting of alum ($Al_2(SO_4)_3.12H_2O$), calcium oxide (CaO) and ferrous sulphate ($FeSO_4$). Furthermore, the material used in the *mordanting* process is the detergent brand Attack Jaz1 and soda ash (Na_2CO_3).

2.2. Method

2.2.1. Extraction of mahagony bark

Preparing extractor-evaporator tanks, stoves and raw materials to make the extract of mahogany bark. Put 1 kilogram of material into the evaporator-extractor tank then put water into the extractor-evaporator tank of 10 litters or up to the marking mark on the estimating tank. Close the extractor-evaporator tank with the tank cap. Turn on the stirring motor and stove at the bottom of the extractor-evaporator tank. Heats until the temperature reaches 100 ºC. Maintain a temperature of 100 ºC for 1 hour for the extraction process. Extracting and evaporating the water contained in the extract to obtain concentrated extract. After the process is complete, turn off the stove and the stirring motor. Open the extractor cover and cooled down for 30 minutes. Extracting the extract through the tap at the bottom of the extractor, then storing the extract in a bucket and inserting it into the jerry can. Take the residue in the form of the remaining mahogany bark which is accommodated in the filter tank in the extractor set tools.

2.2.2. Mordanting

Dissolving the detergent as much as 3 grams in 3 litters of water then soak the fabric into the detergent solution overnight. Then wash the fabric and squeeze the fabric. Preparing a *mordanting* solution by preparing 10 litters of water, 100 grams of alum and 30 grams of soda ash and the solution is boiled. After the water was boiled, the fabric that has been soaked overnight is boiled in a *mordanting* solution for ± 15 minutes. The *mordanting* solution and the fabric were left on overnight, then the fabric was dried

2.2.3. Application of Natural Dyes on Fabric

Cutting the fabric to be given a mahogany bark dye. Dip a fabric into the dye solution and soak it for 5 minutes with 5 dips.

Figure 1. Coloring of premise fabric in mahogany dyes 5 times of dyeing

2.2.4. Fixation

Making a fixator from alum, calcium oxide, and ferrous sulphate by dissolving 30 grams of alum / calcium oxide/ ferrous sulphate in 1 L of water, soaking fabric for 10 minutes to a concentration of 30 g / L. Dissolving 60 grams of alum / calcium oxide / ferrous sulphate in 1 L of water, soak a fabric for 10 minutes for a concentration of 60 g / L. Dissolving 90 grams of alum / calcium oxide / ferrous sulphate in 1 L of water, soak a fabric for 10 minutes for a concentration of 90 g / L.

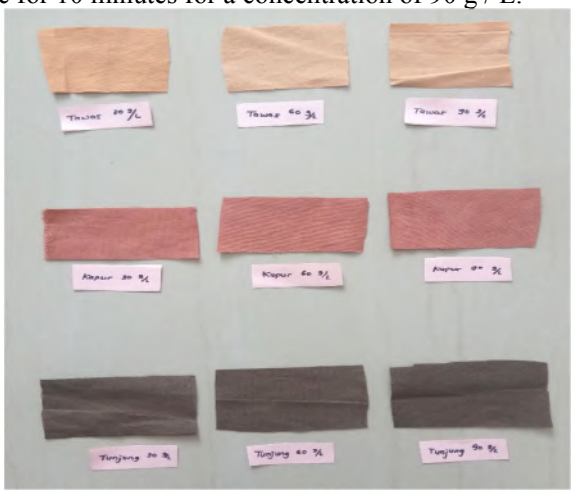

Figure 2. Fixation results with various types and concentrations

2.2.5. Color Fading Resistance to Rubbing

First connecting the Crockmeter Plug to an electric current source. Test sample the dyed fabric is cut according to the provisions of the size 7.5 x 25 cm and 5 x 5 cm for the white fabric for the colored fabric scrub. Then the fabric is stretched and the edges are fastened to the tool. Attach a white fabric measuring 5x5 cm in the existing envelope in the rubbing section. Dry Rub test 5x5 cm white fabric pairs on the existing sheath on the rubbing section without being wet while the Wet Rub Test, 5x5 cm white fabric moistened with water and then dry with a tissue so that the condition is still moist and installed in the rubbed envelope. bring up zero on the counter and place the scorer on the material you want to test. Turn on the tool by pressing the ON button (Green color). If the number of rubbing is in accordance with the plan which is 10 times rubbing, stop the tool by pressing the OFF button. (Red). Color fastness testing can be rubbed with a dry system and wet rubbing. That is soaked in a white fabric with a size of 5x5 cm. After testing, the material that has been tested is then assessed for color staining that has stuck to the white fabric using a grey scale measuring instrument (Grey Scale) what is the value

of the staining? example value 3 (middle weak), Value 5 (very strong, means no fade / no stains). After completing the test, the crockmeter engine which has been connected to an electric current is to be removed from the socket.

2.2.6. Color Aging Test

First connecting the Computer Plug and Spectrophotometer to an electric current source. Turn on the computer that already has the UV-VIS PC program. Turn on the Spectrophotometer which is already connected to the computer. Then click 2x on the UV-VIS PC program image that is already on the monitor screen. Open the CONFIGURE menu, select PC CONFIGURE, exit the menu and fill in the printer type column that you want to use then click OK. Open the CONFIGURE Menu, select UTILITY, exit the UV-VIS PC menu, select ON (meaning: in the UV-VIS PC, the light should be on / all) then wait until the green mark on the monitor turns on for ± 10 minutes, then just click OK Open the CONFIGURE Menu, select PARAMETER Exit the menu and fill in, for example select (R%) and then fill in the ring for the star column filled in 780nm and for the finish column filled in 380nm then in OK. Before testing to the fabric that has been colored, to put the chart / blank, the original ORIGINAL / STANDARD white fabric 5x5 cm is clamped to the ISR box inside the UP-PC then click BASELINE awaited until it shows the number 380nm. Beginning the test enter a sample fabric that has been varied or colored 5x5 cm in size is clamped on the ISR box on the UV-VIS PC then clicked STAR, wait until it is detected until the finish is 380nm, then the menu name file comes out, column 1 is named for the sample code and column 2 is given the name of the owner of the test sample. Then press OK. Then further testing with fabric samples that have varied and steps as in no.9 and so on. To find a graphic that is not yet visible on the monitor screen, open the PRESENTAGE menu, select RADAR, it will automatically display the graphic image that has been tested earlier. To find the file that has been tested open MANIPULE select PEAK PICK on the click and the image menu will appear then move up to the top so that the graphic image and the value of the test results are visible. To find the value one of the strongest R% numbers is taken, is the last order range between 1-5, the lowest, the smaller the R% value the fabric gets darker / darker. Conversely, if the value of R% is greater the color of the fabric becomes brighter or toward color to white. How to print, open OUTPUT in PEAK PICK, select the GRAPHIC PLOT menu, click directly out of the data and graphics.

3. Results and discussion

Color fastness is assessed by comparing the color changes that occur with color change standards issued by the International Standards Organization (ISO) and made by the Society of Dyers and Colorists (S.D.C) in the United Kingdom and the American Association of Textile Chemists and Colorists (AATCC) in the United States. The color change standard issued is the gray scale standard to assess the color change of the laundry and the staining scale to assess the color change due to staining on the white fabric. From the analysis results will be obtained figures that indicate the level of fastness.

Figure 3. Grey Scale

Table 1. Color Change Assessment on Gray Scale Standards

No	Color Fastness Value	Color Difference (CD)	Tolerance of Work Standards	Evaluate Color Fastness
1	5	0	0,0	Very Strong
2	4-5	0,8	± 0,2	Strong
3	4	1,5	± 0,2	Strong
4	3-4	2,1	± 0,2	Middle Strong
5	3	3,0	± 0,2	Middle Weak
6	2-3	4,2	± 0,3	Weak
7	2	6,0	± 0,5	Weak
8	1-2	8,5	± 0,7	Very Weak
9	1	12,0	± 1,0	Very Weak

The results of testing the dyes of mahogany bark on premise fabrics are done in two ways, namely testing the fabric of dry and wet rubbing with Grey Scale (GS / CD) and testing the fabric color aging. The process of testing for rubbing uses a tool called Crockmeter. Whereas the color aging test uses a UV-VIS PC Spectrophotometer. From the dyestuff testing process on the fabric that has been done, the dyestuff test results are obtained which can be seen in the table below.

Table 2. Test results for color fastness test against dry rubbing

Natural Dye	Concentration (g/L)	Fixator					
		$(Al_2(SO_4)_3.12H_2O)$		CaO		$FeSO_4$	
		GS	CD	GS	CD	GS	CD
Mahagony	30	4-5	2,0	4	4,0	4	4,0
	Value	Strong		Strong		Strong	
	60	4-5	2,0	4	4,0	4	4,0
	Value	Strong		Strong		Strong	
	90	4-5	2,0	4	4,0	4	4,0
	Value	Strong		Strong		Strong	

(CD = Color Difference)

The results of fabric color fastness testing against dry rubbing with Grey Scale, fabrics that have optimal color fastness on mahogany dyes are fabrics that are fixed using alum fixers with grades 4-5 (Strong) in various concentrations.

Table 3. Test results for color fastness test against wet rubbing

Natural Dye	Concetration (g/L)	Fixator					
		$(Al_2(SO_4)_3.12H_2O)$		Cao		$FeSO_4$	
		GS	CD	GS	CD	GS	CD
Mahagony	30	3-4	5,6	3	8,0	2-3	11,3
	Value	Middle Strong		Middle Weak		Weak	
	60	3-4	5,6	3-4	5,6	3	8,0
	Value	Middle Strong		Middle Strong		Middle Weak	
	90	3	8,0	3	8,0	3	8,0
	Value	Middle Weak		Middle Weak		Middle Weak	

*(CD = Color Difference)

The results of fabric color fastness testing against wet rubbing with Grey Scale, fabrics that have optimal color fastness on mahogany dyes are fabrics that are fixed using alum fixators at concentrations of 30 g / L and 60 g / L with grades 4-5 (Strong) and calcium oxide fixator at a concentration of 60 g / L. Fabrics with mahogany dyes fixed with tide fixators have discolored at the time of testing, causing a significant color difference from the original color.

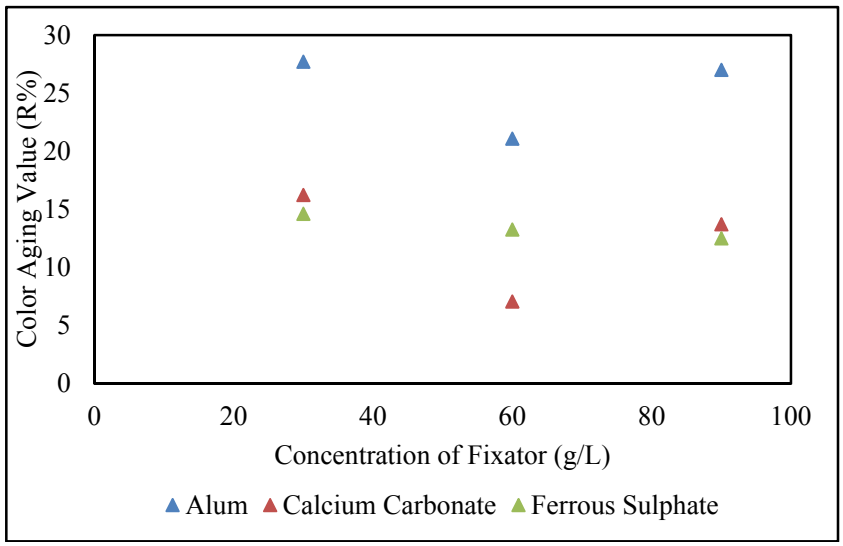

Figure 4. Graph of fixator concentration (g/L) versus color aging value (R%)

Color aging test aims to determine the amount of dye absorbed in the material. Measurements were made with a Spectropothometer (UV-VIS PC). Retrieval of the value of R% is taken from one of the strongest R% number values, which is the last order range between the lowest 1-5. The smaller the value of R%, the color of the fabric is getting darker / darker. While the greater the value of R%, the color of the fabric is brighter or towards the color to white. Based on the data of the color aging test results, the fabric that has the smallest R% value is fabric fixed using a calcium oxide fixator at a

concentration of 60 g / L with an R% value of 7.06. While the fabric which has the highest R% value is the fabric which is fixed using alum fixator at a concentration of 30 g / L with an R% value of 27.70.

Based on the data of the color aging test results, the fabric that has the smallest R% value is fabric fixed using a calcium oxide fixator at a concentration of 60 g / L with an R% value of 7.06. While the fabric which has the highest R% value is the fabric which is fixed using alum fixator at a concentration of 30 g / L with an R% value of 27.70.

4. Conclusion

According the result from the value of R% (color aging) and color fastness test against wet and dry rubbing, it can be concluded that alum and calcium oxide are the strong fixators and the optimal concentration is 60 g / L in dyeing batik fabric by natural dye of mahogany bark.

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Design and Development of Tourism Geographical Information System of Semarang City Based on Android Mobile

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Abstract. The development of information technology that exists today is very rapid, making us to keep abreast of the development of these technologies. Technology is able to present all information quickly and instantly, leaving old patterns such as gathering information manually which may require more time. Information technology today is very effective and efficient as indicated by the speed of processing time and the accuracy of the information needed. One of them is the information about tourist attractions, which is currently increasingly in demand by people who want to vacation with friends, relatives and family. However, the lack of information about the location of attractions that want to be visited, especially for potential tourists from outside the area of Semarang, make the author interested in design and creating the Semarang City Geographic Tourism Information System Based on Android Mobile to facilitate the search for the nearest route to the desired tourist attraction. The method used is using the Geographic Information System based on the data from the Semarang City Culture and Tourism Service. The Semarang City Tourism Geographic Information System Based on Android Mobile is a solution to problem solving as a medium to obtain information and tourism locations in the Semarang, which is applied in Android Smartphone devices, especially for the people from outside the city of Semarang.

Keywords: Geographic Information System, Semarang City Tourism, Android, GIS, Information Technology

1. Introduction

The city of Semarang is the capital of Central Java Province, Indonesia, as well as the fifth largest metropolitan city in Indonesia after Jakarta, Surabaya, Bandung and Medan. As one of the most developed cities in Java in economy, trade, services, industry and tourism as well as being an *interland* in the Central Java region [1]. Semarang is one of the cities that has a maintained cultural heritage. The rapid development in the city of Semarang can be seen from the slogans "Visit Central Java 2018" and "Let's Go Semarang Tourism" which raises a positive impact for the development of tourism. Historic buildings, family tourism, culinary tourism, religious tourism and nature tourism that has been in demand can be an alternative visit by foreign and domestic tourists in the city of Semarang [2].

There are many tourism attractions in the city of Semarang such as Kota Lama / Kota Tua Semarang, Blenduk Church, Lawang Sewu, Kleteng Sam Poo Kong, Kauman Grand Mosque, Tugu Muda and Goa Kreo. The search for an attractions location certainly requires a position in the delivery of geographical information from a tourist attraction. Currently the most widely known online map is Google Maps, which can be accessed easily through various types of web-based and mobile information systems with

the help of the internet. Therefore, by combining the things above it is expected to produce a mobile GIS application that can facilitate the tourists in determining the desired tourist destination, especially in the city of Semarang [3].

The lack of information about the location of tourist attractions is a hindrance for potential tourists, especially those outside Semarang. Information about Semarang tourism still uses print media, which is less effective because it is only limited to certain places and certain events. Modern people who are interested usually seek information from the internet, usually about attractions in the city of Semarang, events in the city of Semarang, Semarang City News, history of the city of Semarang, souvenir shops and hotels in the city of Semarang. Along with the rapid development of technology, the use of the internet can be done anywhere, whether through computers or mobile devices.

Based on the above problems, to help tourists find tourist locations and information on the city of Semarang, a tourism application was made on an Android-based mobile device. This application will provide information about attractions and their information. In addition, this tourism application also displays a map that can help tourists find a route to the tourist destination to be addressed through the Google Maps API and to display / find out the position of the current user by using GPS. In this study, the application development procedure uses the R&D method based on the steps developed by Borg & Gall consisting of Research and information collecting, Planning, Develop preliminary form of product, Preliminary field testing, Main product revision and Main field-testing.

2. Methods

The model that will be developed is based on the Research and Development (R&D) model of Borg and Gall. The design development with the R&D design of Borg and Gall has the aim to develop and validate the product. The Development and Research Model (R&D) has 10 steps including Research and information collecting, Planning, Developing preliminary forms of products, Preliminary field testing, Main product revision, Main field testing, Operational product revision, Operational field testing, Final product revision, Dissemination and implementation. The system development carried out in this study only reached the six stages to produce the final product in the form of a prototype, so it did not reach the product implementation stage. To arrive at the product implementation stage further research can be carried out. The six steps of the R&D model are described in Figure 1.

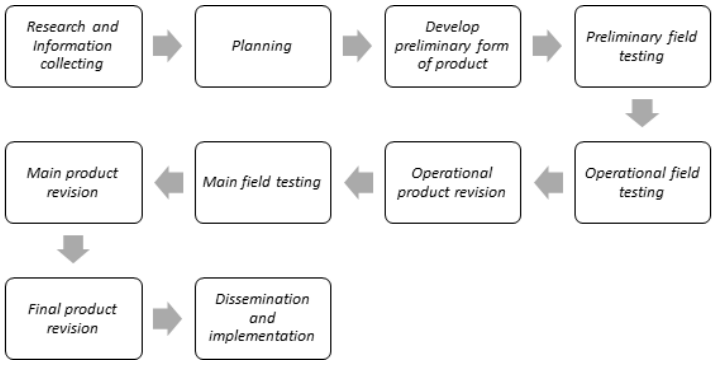

Figure 1. Research and Development Model

3. Results and discussion

3.1. The design of Tourism information system

The following describes the application design before applied to the programming language. The design of the application is to arrange the layout of the components in the application. The components in question are buttons, images, images and other important components.

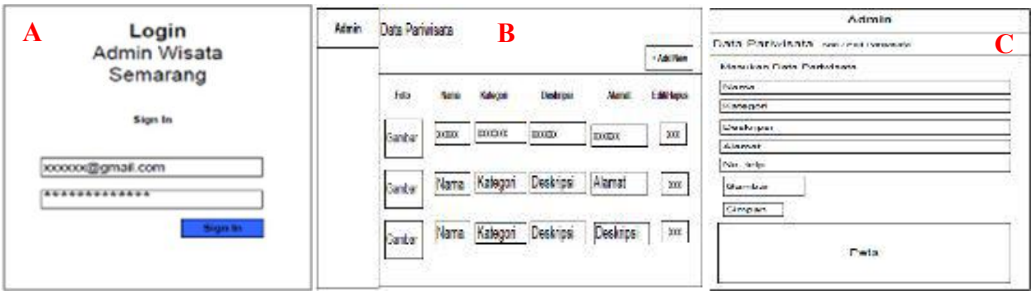

Figure 2. Layout Design for Tourism Information System; (A) Android's main page, (B) Tourism Data Layout, (C) Tourism Data Input Layout

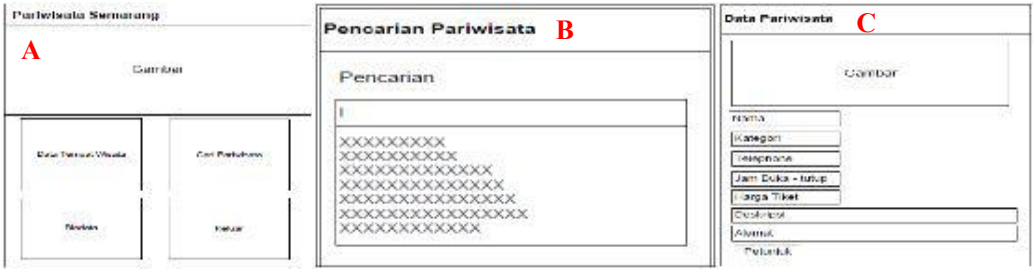

Figure 3. Layout Design for Tourism Information System on Android; (A)Main Page, (B) Tourism Data search Layout, (C) Tourism Data Input Layout

Figure 4. Layout Design for Tourism Information System on Android; Tourism Route page

3.2. The implementation of Tourism information system

This chapter contains the results of the design and implementation of the tourism information system. After carrying out each stage in the method, we developed an android application based information system to access the tourism information of Semarang.

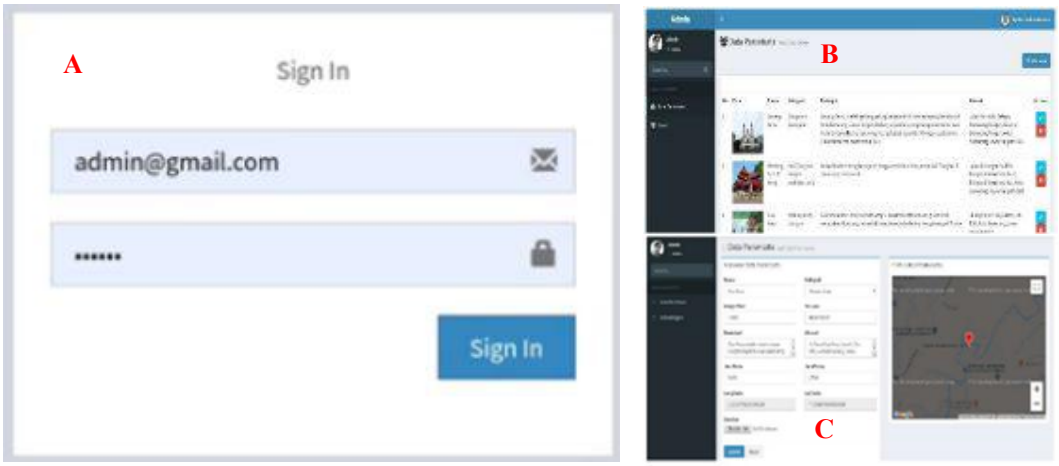

Figure 5. Tourism Information System administrator site; (A) Admin login page, (B) Main Menu page and (C) Admin page for Tourism Data Input

Figure 2(A) above shows the login page for administrators that used by the administrator to enter the system by using email and password. After the admin has successfully logged in, it will shows the admin page used to display, submit, edit and delete tourism data, as depicted in Figure 2(B). Administrator can submit tourism data using admin page for tourism data input in figure 2(C) like names, categories, opening and closing hours, location on the map and photos.

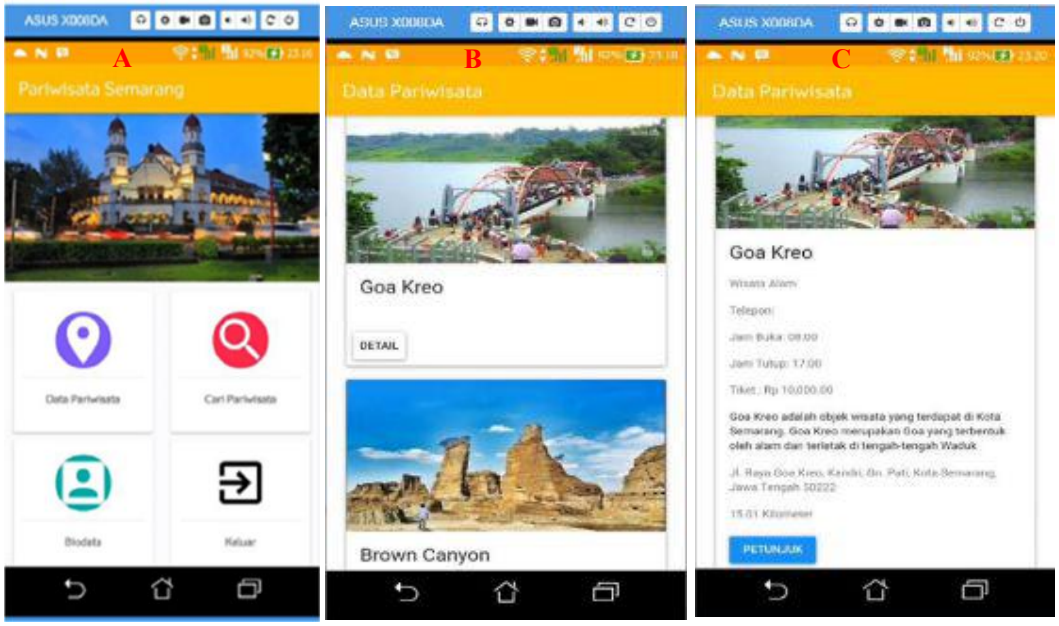

Figure 6. Tourism Information System on Android; (A) Main page, (B) Tourism site list and (C) Description of tourism site

Figure 3(A) shows the main display of tourism applications on android. There are four buttons consisting of tourism data, search for tourism, biodata and Exit. Tourism data button displays the tourism site list as depicted in figure 3(B). Detailed information for each tourism attractions as tourism name, category, telephone, opening and closing time, ticket price, description, address and estimated distance from the user's current location, as shows in figure 3(C), can be accessed by using detail button on the tourism site list.

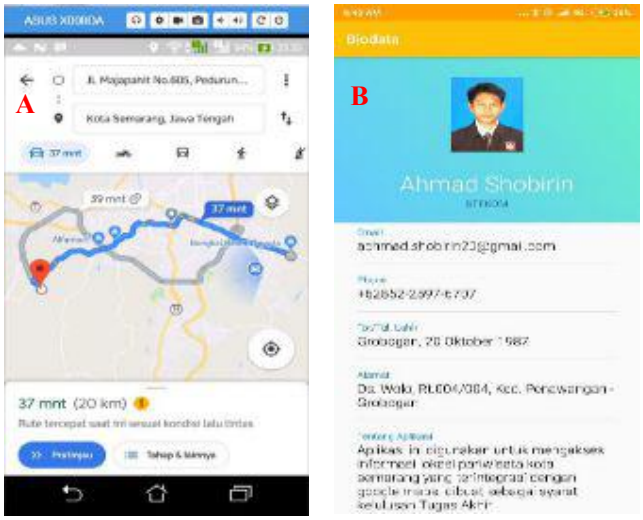

Figure 7: Tourism Information System on Android; (A) Tourism Route page and (B) Admin biodata

The tourist route page displays the step-by-step route, the total time and distance that must be taken from the user's place to the tourist destination. The biodata page contains information about the Semarang-based tourism geographic information system application. The information displayed in the form of a description of the application and Application developer biographies.

4. Conclusion

Based on the description of the chapters above and after conducting a field trial the results of the Semarang Mobile-Based Android Mobile Geographic Information System Design for Tourism Users can be summarized as follows:

1. Design and Development of Geographic Information Systems for Semarang City-Based Tourism, Android Mobile is an application that can display information and locations of Tourism in the city of Semarang to users.
2. Design and Development of Semarang City-based Android Mobile Geographic Information System is able to provide location information of Semarang city tourism map with the search for the nearest route.

This system has limitations such as:

1. The application requires internet connection to search for a list of tourism places and search for the nearest route via GPS.
2. This research is focused and limited to the search for tourism locations in the city of Semarang.

Based on the results of research and design of applications that has been built, the suggestions for further research are:

1. This application is expected to be developed further to expand tourist areas in this case not only the Semarang area but also the Central Java.
2. A feature that can be developed for further research is the use of Google maps to appear in more

than one tourism location so that application users can see Semarang city tourism instructions with the option of multiple tourism points directly.

Acknowledgements
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Rain Prediction Using Rule-Based Machine Learning Approach

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Abstract. Rain prediction is an important topic that continues to gain attention throughout the world. The rain has a big impact on various aspects of human life both socially and economically, for example in agriculture, health, transportation, etc. Rain also affects natural disasters such as landslides and floods. The various impact of rain on human life prompts us to build a model to understand and predict rain to provide early warning in various fields/needs such as agriculture, transportation, etc. This research aims to build a rain prediction model using a rule-based Machine Learning approach by utilizing historical meteorological data. The experiment using the J48 method resulted in up to 77.8% accuracy in the training model and gave accurate prediction results of 86% when tested against actual weather data in 2020.

Keywords: rain prediction, machine learning, J48, data mining

1. Introduction

Rain prediction is an important topic that continues to gain attention throughout the world. The rain has a big impact on various aspects of human life both socially and economically, for example in agriculture, health, transportation, etc. Rain also affects natural disasters such as landslides and floods. So much the impact of rain on human life, then we need a model to understand and predict predictions to provide early warning in various fields/needs such as agriculture, transportation, etc. Modeling can be made based on historical weather data that has been recorded by meteorological stations that are scattered in various locations in Indonesia. This data has been provided by the Climatology, Meteorology, and Geophysics Agency (BMKG) to be accessed by the public for various purposes including research purposes. It is known that Machine Learning / Data Mining can be used for weather prediction and forecasting[1][2]. This study aims to build a rain prediction model using a data mining approach by

utilizing historical meteorological data.

2. Methods

2.1. Research on Weather Predictions

Several studies on weather/rain prediction have been conducted. Some studies use a statistical approach while others use a data mining approach. Research on weather/rain prediction with a data mining / statistical approach is summarized in Table 1. In weather timeseries research, there are statistical approaches such as ARIMA, Exponential Smoothing[3], etc and Data Mining / Machine Learning such as Artificial Neural Networks, etc. [4]. Some studies combine the elements of weather prediction to be associated with certain phenomena such as Dengue Fever [5], agriculture [6], dan foods[7].

Table 1. Research on weather/rain prediction

Reference	Variables	Method
[8]	Temperature	Fuzzy
[9]	Barometric pressure, temperature, dew point, humidity, wind speed	Fuzzy
[2]	Temperature, rainfall, humidity, exposure time, duration of fog, evaporation, wind, atmospheric pressure, number of clouds	Decision trees, bagging, random forests, and boosting
[10]	Minimum temperature, maximum temperature, rainfall	Multiple Linear Regression
[11]	Temperature, air pressure, relative humidity, vapor pressure, wind speed	Bayesian
[12]	Maximum humidity, average humidity, rainfall	Naïve Bayes
[13]	Temperature, wind speed, wind direction, humidity, atmospheric pressure, rainfall	Multiple Linear Regression
[14]	Maximum temperature, minimum temperature, evaporation, wind speed, cloud cover	J48, ANN, dan Naïve Bayes

2.2. Decision Tree

The Decision Tree (DT) model has a top-down hierarchical structure that describes the rules for dividing large data sets into small groups given a specific target variable. There are three distinct algorithms for categorical target variables in the DT model, i.e Entropy Reduction, Gini, and Chi-square tests. Previously, research on weather forecasting and climate change found that models produced using DT have small errors compared to other techniques in predicting data mining with large historical data [15], [16].

The DT model is one of the most powerful and useful for predictions that explore large and complex data. The mechanism in the DT model is transparent and is produced easily to understand the model for researchers. Besides, the DT model can convert raw data into information in a simple way, by complying with a set of rules that can be read by humans. The resulting structure represents a decision or rule for the classification of datasets. These rules are made to make groups as homogeneous as possible in terms of response variables. At each step, the input variable is used to divide the observations into groups. If the specified input values are identified to have a strong relationship with the response values, then all of these values are grouped in the same branch in the decision tree.

Trees can fit better as the grouping of observation data split into smaller groups (i.e 'branches'). In this situation, the DT model will remember data patterns rather than generalize them. The pruning algorithm in the DT model helps overcome the problem of overfitting by pruning trees using certain algorithms, namely, CART, CHAID, and C4.5. CART and CHAID both use the Gini Index and Chi-squared test, respectively, to classify records in the target variable. This research uses the C4.5 / J48 method which uses the measure of Entropy and information gain.

2.3. C4.5 / J48 Algorithm

C4.5 is the successor of the Iterative Dichotomiser 3 (ID3) algorithm developed by the same author, Ross Quinlan, in 1993 [17]. This has several improvements over the original ID3 such as the ability to handle continuous and discrete attributes and the ability to prune trees after it is created. C4.5 works by creating trees based on entropy and information gain to select which attributes are useful in classifying the data. Entropy is a measure of the heterogeneity of data, while information-gain is a measure of how much information is obtained by comparing entropy before and after separating the dataset based on certain attributes. Formulas for entropy and information-gain are shown in (1) and (2) respectively. Pruning in C4.5 is based on the confidence factor. Pruning is useful for minimizing model overfitting and reducing tree size but in lower model accuracy costs. The well-known implementation of C4.5 is the J48 function which is written in Java is provided within the Waikato Environment for Knowledge Analysis (WEKA) software [18]. The pseudocode for the C4.5 algorithm is shown in Algorithm 1 [19]. J48 will produce a tree by which the rules could be easily read by humans. This J48 method has also been used to find rules for forest fire cases in Indonesia[20]. Research [21] also showed that a decision tree is very suitable for rain prediction.

$$Entropy(S) = \sum_{i=1}^{c} - p_i \log_2 p_i \tag{1}$$

$$Gain(S, A) = Entropy(S) - \sum_{v \in Values(A)} \frac{|S_v|}{|S|} Entropy(S_v) \tag{2}$$

Algorithm 1: C4.5

Input: an attribute-valued dataset D
1: Tree = {}
2: **if** D is ”pure” OR other stopping criteria met **then**
3: terminate
4: **end if**
5: **for all** attribute a ∈ D **do**
6: Compute information-theoretic criteria if we split *a*
7: **end for**
8: a_best=Best attribute according to above-computed criteria
9: Tree = Create a decision node that tests a_best in the root
10: D_v = Induced sub-datasets from D based on a_best
11: **for all** D_v **do**
12: Tree v = C4.5(D_v)
13: Attach Tree v to the corresponding branch of Tree
14: **end for**
15: **return** Tree

The research methodology is shown in Figure 1. Daily historical weather data was obtained from the BMKG website for the Tanjung Mas meteorological station, in Semarang City, Indonesia. The original data consisted of 12 attributes, but for this study, only 8 attributes were used, as shown in Table 1. The attribute of wind direction was not used since the numerical scale was not appropriate for this study. One additional attribute is added, i.e the class which shows whether it rained or not on each particular day. The class is obtained by evaluating the RR (rainfall) attribute column, if RR> 0 then class = ‘rain’; otherwise, class = ‘norain’. Data cleaning is done to remove entries with missing values. Data is then

stored in CSV format and then converted to the ARFF file format to be able being processed using the WEKA software. Experiments were carried out using the J48 function under the classification tab. The attributes of the meteorological data are shown in Table 2.

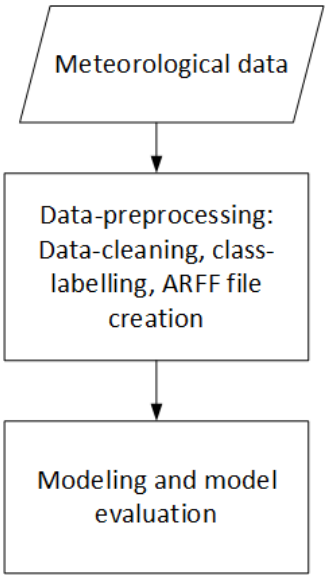

Figure 1. Research Methodology

Table 2. Attributes of the meteorological data

Attribute	Data type	Description
Tn	Numeric	Minimum temperature
Tx	Numeric	Maximum temperature
Tavg	Numeric	Average temperature
RH_avg	Numeric	Average Humidity (%)
RR	Numeric	Rainfall (mm)
ss	Numeric	Sun exposure time (hours)
ff_x	Numeric	Maximum wind speed (m/s)
ff_avg	Numeric	Average wind speed (m/s)

3. Results and Discussion

Meteorological data gathered from the year 2013 to 2019 with a total of 2536 rows of data were used in this experiment. Evaluation of model accuracy is done by using the 10-fold cross-validation for the training data and tested against actual weather data in 2020. The training model gives an accuracy of 77.8% whereas the results of experiments against 2020 data gave an accuracy of 86%. The lower accuracy of the trained model might be caused by the overfitting of the model or that there is a huge variation in the large amount of training data being used to build the model. These findings also agree with another research which showed that decision trees and k-mean clustering are best-suited data mining techniques for weather data, with the increase in the size of the training set, the accuracy is first increased but then decreased after a certain limit [21]. The model also showed that the factors that predict rain the most are the average humidity (RH_avg), followed by the minimum temperature (Tn). The hight accuracy achieved by the J48 method is in line with other research which stated that the Decision Tree model is better as compared to the other predictive models [14]. The resulted tree which also shows the

rules is shown in Figure 2. The model accuracy on various minumum number of cases per leaf is shown in Table 3.

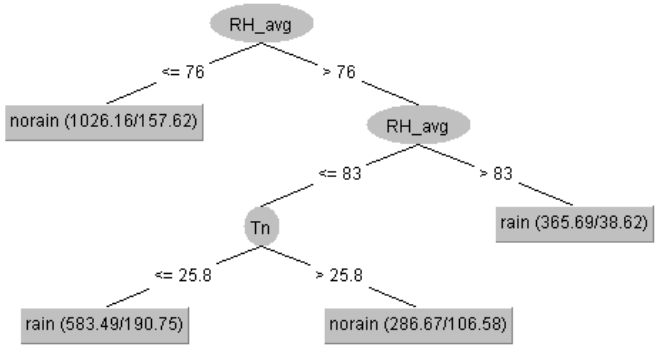

Figure 2. The (simplified) decision tree produced by J48 (with minumum case of 10 per leaf)

Table 3. The model accuracy on various number of minimum case per leaf

Minimum cases per leaf	Model accuracy (%)
2 (default)	76.0
5	76.1
10	77.4
20	77.7
100	77.8

4. Conclusion

A rain prediction model is very useful for human activities. This research attempted to build a rain prediction model by using a rule-based machine learning approach applied to historical meteorological data. The decision tree model produced by the J48 algorithm could give an accuracy up to 77.8% from the training data and give an accuracy of 86% when tested against actual weather data in 2020. The result showed that rainfall is mainly affected by the average humidity and by minimum temperature for a particular day of observation. This result gave us a better understanding of the phenomenon of rain and the model could be used for several purposes such as in agriculture, transportation, etc.

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Management of Coastal Areas with Sustainable Marine Ecotourism Development in Purworejo Regency, Central Java, Indonesia

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Abstract. The beach is a favorite tourist destination for the Indonesian people. As Indonesia is blessed with many beaches which attracts people to visit. Indonesians usually come to the beach in the holiday to fish, see beautiful scenery, and play around. Central Java Province in Indonesia has a beach cluster situated to the north and south of the Java Island. Jatimalang Beach is the south coast of Java which has excellent natural beauty, which is located in Purworejo Regency. This research is focused on the beach facilities and infrastructures, tourist's ecotourism awareness, and environmental sustainability management of the Jatimalang Beach Purworejo. The study was carried out in November till December 2019 by using the qualitative research method. Information discovered during fieldwork are used to direct data collection. Qualitative researchers, are closely engaging with the environment being examined. This work was conducted through observations and interviews with tourist at Jatimalang Beach, as well as a literature review. The results showed that the facilities and infrastructure found in Jatimalang Beach were the presence of lifesavers, waste, parking lots, freshwater swimming pools for children, toilets, electrical facilities, and worship places. In addition, tourists are often willing to preserve nature and the sustainability of marine tourism on the Jatimalang Beach, however many of them do not understand the importance of ecotourism and need to be educated again.

Keywords: ecotourism, beach, infrastructure facilities, sustainable tourism

1. Introduction

Purworejo is a regency located on the southern coast of Central Java, which has many tourist destinations with beautiful views. The study was conducted at Jatimalang Beach located in Jatimalang Village, Purwodadi District, Purworejo Regency, Central Java, Indonesia. The weather conditions in the Jatimalang Village are hot and humid [1]. Jatimalang Beach is included in the Integrated Maritime

Region category in the RTRW Central Java Province [2]. In addition, establishes Jatimalang Beach as Purworejo District's tourism destination that can be more developed and be added to the potential destination, thus can increase the tourism sector [3]. The integrated coastal management can increase local own-source revenue [4]. The problems found in the Jatimalang Beach are the badly managed infrastructure for coastal area development, the lack of public support for the tourism industry, the non-optimal coastal development planning, the inadequate some facilities, and also a lack of synergy in tourism management [1]. Based on these problems, the solutions and recommendations which is related to the Jatimalang beach tourism management are needed that prioritize environmental aspects so that they can provide an overview for the government to manage the integrated and sustainable coastal tourism areas.

2. Methods

This research describes the variables that are appearing in the study area. The descriptive research mentions the society problems, the activity relationship, attitudes, views, and processes that are currently happening and also the effects of some phenomenon. The research method used is the qualitative research methods, which the data collection is guided by the facts found at the time of research in the field [5]. The qualitative research illustrates the interpretation and meaning of the current situation, which emphasizes the role of researchers as a major part of the research. Data collection was carried out by the observation, using an open questions lists, and interviews with beach visitors focused on the way of thinking from respondents. Qualitative researchers, interact intensely with the reality under study [6]. The ecology of the environment, culture, and social economy as a basis is taken into account in the analysis of the management and development of sustainable marine tourism. Figure 1 presents the research location in the Jatimalang Beach, Purwodadi District, Purworejo Regency. The research was conducted on November to December 2019, by using the field observations and primary data collection through the interviews with the tourists, also the secondary data are found by the literature review. This data was taken in the form of photos, questionnaires related to coastal tourism, data on ecological conditions, convenience, participation, and perception in protecting the environment. The study area, located in Jatimalang Beach, Purwodadi District, Purworejo, Indonesia presented in Figure 1.

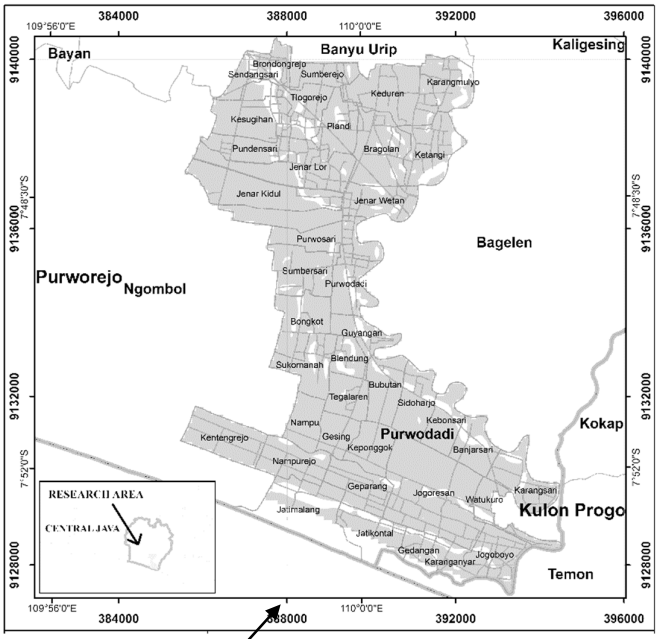

Figure 1. The study area, located in Jatimalang Beach, Purwodadi District, Purworejo, Indonesia [7]

3. Results and Discussion

3.1. Result

3.1.1. Land Use

Jatimalang Village has an area of around 150 Ha with the land use composition divided into four main groups, namely rice fields with the total area of 51.75 Ha, dry land with 98.35 Ha, 8.12 Ha of buildings, and 41.23 Ha of gardens usage. More population increase, the more land requirements needed by the population, however the availability of the land is very limited [8]. The increasing usage of the dry land is in line with the residential land usage increase. The expansion of dry land agriculture is the conversion activity of the dryland agriculture with bush [9]. In addition, the raise of the plantations is also the majority conversion of shrubs [10]. The yard farmland in the study area is planted with the fruit trees with the utilization of the fruits for the population food [1]. Figure 2 shows the usage of the land use in Jatimalang Village.

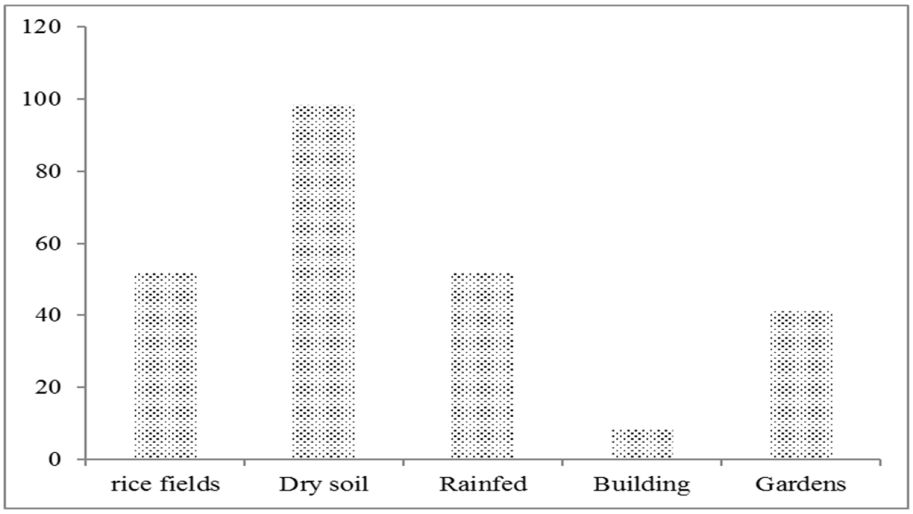

Figure 2. Land Use in Jatimalang Village (Ha)

3.1.2. Total Population

The total population in Jatimalang Village in year 2018 is 1189 people, consisting of 623 males and 566 female residents. The highest composition of people in the productive age of 35–39 years old is 127 people, following by the teenage age of 10–14 years old with 124 people, while the people of 70–74 years old was the lowest composition with 24 people. Figure 3 displays the number of residents and the composition of the population based on their age in Jatimalang Village. The residents are mostly work in the tourism sector by selling the food and drink in the beach. Thus, some of them also work in the fields of giant prawns and fish cultivation, and also as the farmers. The Jatimalang people also utilize the brown sugar in the coconut trees to be sold in the market [1]. Figure 3 shows the Number of residents in Jatimalang Village

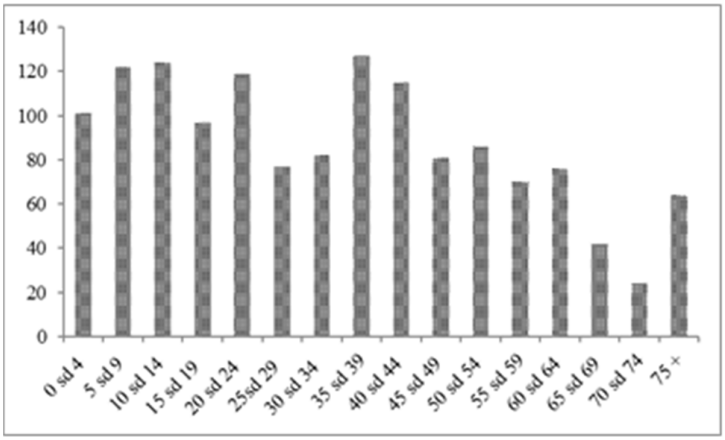

Figure 3. Number of residents in Jatimalang Village

3.1.3. Visitors

In the last five years, the highest number of tourist arrivals in Jatimalang Beach was in July with the total of 24,006 people, followed by 17,211 people on June. The visitor took the advantage of the holidays held on these months to travel to the beach. The high number of tourists visit also occurred during the new year moment in January with 13,676 people and on December with 14,020 people. The total number of tourists arrivals on Jatimalang Beach is presented in Figure 4.

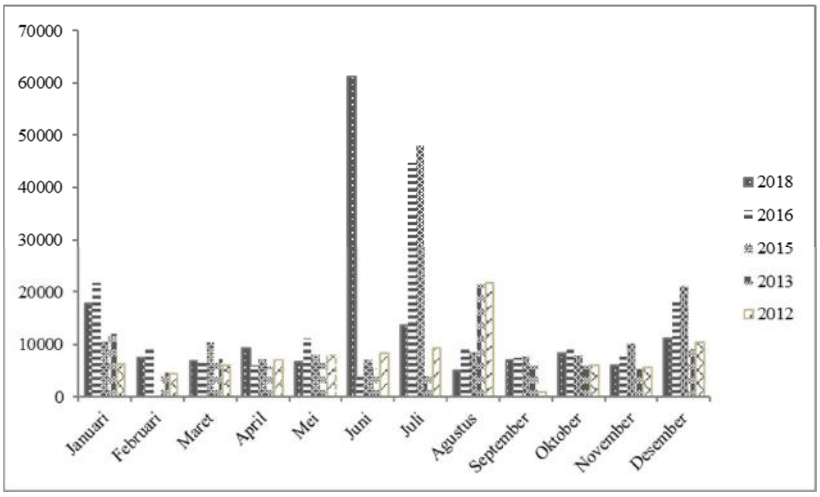

Figure 4. Number of tourist arrivals in Jatimalang Beach in 2012-2018

3.1.4. Visitors

The tourist who have visited Jatimalang Beach gave different perception on the supporting infrastructure and facilities. This result is based on the availability of the place of worship, trash bin, electricity, connecting roads, food stalls, transportation, freshwater, and also the housing service for the tourists. The perception for the facilities expressed by the tourist is among the option of unknown, lack, enough, good, and excellent, which can be shown in Figure 5. It can be observed from Figure 5 that many of the tourists did not know where the hostelry, because of they go home straightly after finish playing in the beach. Thus, the freshwater availability in order to washing their hand are already considered good and also the restaurant are assumed to be adequate even on the weekend or holiday. However, the worship

places, trash bins, and electrical installations are need to be improved and to be kept clean. The food stalls around the beach has provided a menu of seafood, grilled fish freshly [11] from the local fishermen. The tourism management and strategies depend on the situational factors, including social aspect, resources, and facility impact. If some tourism already has adequate facilities, the action on the environmental impacts must be immediately sought for the solution in the short period of time [12]. The Tourist Facilities Perception of beach infrastructure facilities is presented in Figure 5.

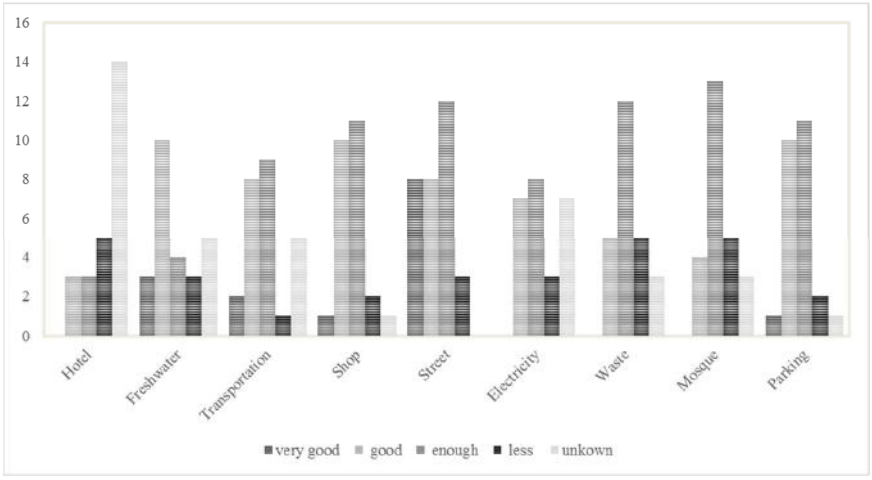

Figure 5. Graph of Tourist Facilities Perception of Beach Infrastructure Facilities

3.1.5. Tourist Respondents' Perception of Beach Scenery

The tourists are interested with the beautiful condition of Jatimalang Beach, the natural beauty of the hill and the potential of fisheries. Futhermore, they concern about the seawater, sand, and the coastal plants including the coconut trees and spruce. The sand in Jatimalang Beach is a vast area and unfortunately it is not being maximized yet. The condition of the sand area is wide, flat, close to the tourist area, abundant sunshine, and shallow water surface [13]. Figure 6 mentions about the attractiveness of Jatimalang Beach for tourists.

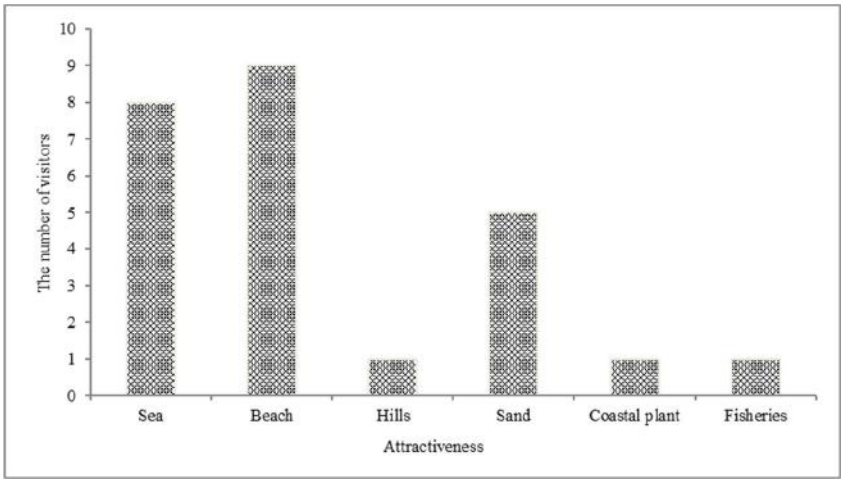

Figure 6. Graph of Attraction of Jatimalang Beach for Tourists

3.1.6. Tourist Respondents' Perception of the Activities

Many activities done by the tourists on Jatimalang Beach, they like to have a walking around enjoying scenery, swimming, taking photos with their friend, or just relaxing by sit on the sand. Also, the fishing activities are carried out by some community to express their hobby or fulfill the daily economic needs [14]. Tourist perceptions of activities carried out on the beach are presented in Figure 7.

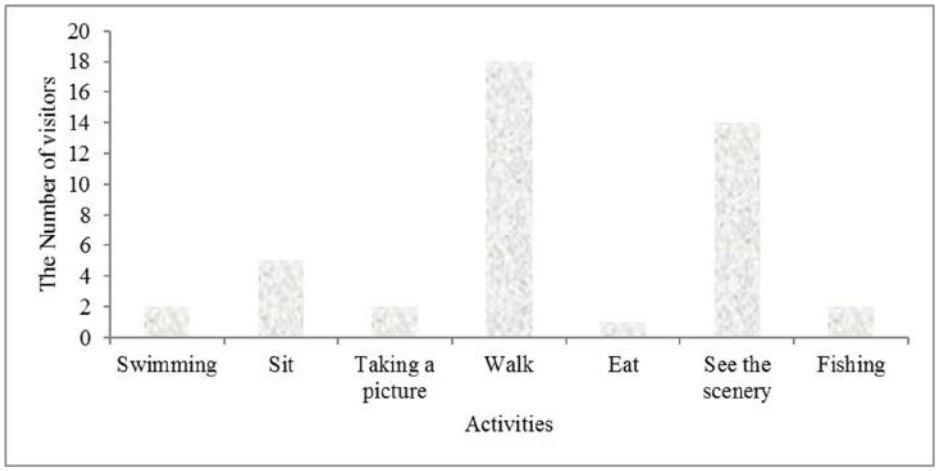

Figure 7. Graph of Tourist Respondents' Perception of the Activities

3.1.7. Tourist Respondents' Perception of the Activities

Based on the Figure 8 which explains about the ecotourism perception, many tourists did not understand the meaning of ecotourism, yet they are willing to be invited to run the activity and to protect the environment. The participation from the tourists and the residents around the beach has a big effect for the development of the local tourism. Thus, the understanding of the environment education, the ecotourism matter, and the landscape of tourism object will have a significant impact on the public participation. The importance of the environment education can play a big role on the ecotourism development [15]. The public opinion that agrees on the tourism development can drive the government to control and take action on how to develop and embrace the other tourists and stakeholders in participating in the advancement of the ecotourism of Jatimalang Beach.

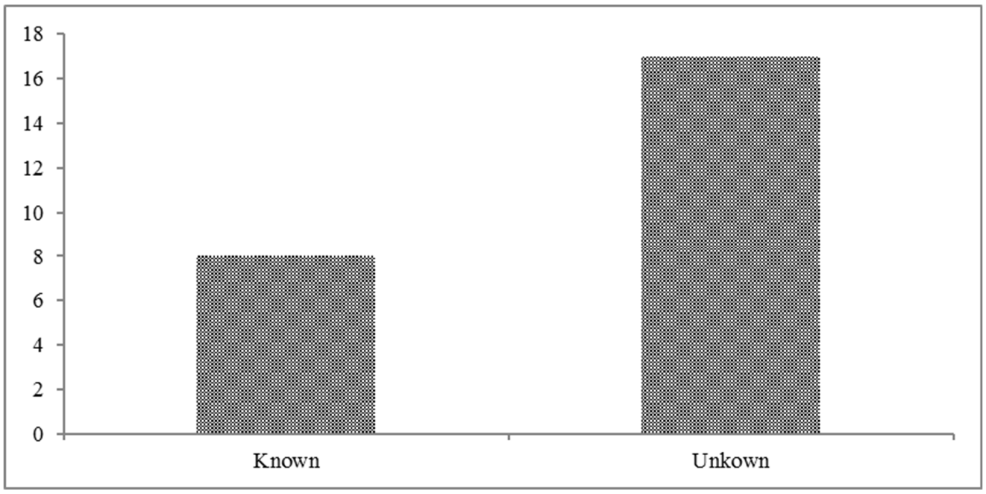

Figure 8. Graphic of Tourist Perceptions of Ecotourism

3.2. Discussion

The concept of sustainable marine ecotourism can be defined as a concept that can be used as an effort to increase the income of coastal communities and driven to be a better integration between the people and the tourism zone. This situation can be performed by using the society as the starting point and the first line to do the activity, in a concept of Once Stop Coastal Tourism. This concept can be used as a tourism policy strategy in some region to improve the welfare, the life quality, and the independency of coastal communities in order to optimize the poverty alleviation efforts in Indonesia. The management should prioritize the empowerment of the surrounding community so that the sustainability and the preservation of the biological environment can be conducted. The One Stop Coastal Tourism is based on the survival of the biological environment according to the 2015 Millennium Development Goals of point 7a [16]. This concept can be organized by empowering the social capital of coastal communities in developing coastal tourism areas, developing e-coastal tourism in an integrated manner with a private-public partnership system, constructing the facilities and infrastructures of the tourism object, as well as the easy access and innovations variety of the coastal area facility. Moreover, the implementation of private-public partnership in the costal tourism industry that leads to the economic empowerment by highlighting the local culture wisdom towards the nature is also important. The ecotourism has proven to be an effective environmental conservation method [17].

This ecotourism management has the positive impact to the society, namely the increase of the public job and the economic business opportunity for the surrounding residents by selling the foods, drinks, souvenirs, becoming the tour guide, or even renting homestay to the tourists. These opportunities will provide additional income for the society and can directly improve their welfare. Also, the government income as the development of the tourism activities in Jatimalang Beach can also be improved from the increasing the taxes and the entrance fees from the tourists visiting the beach. This will later develop the economic condition for the Purworejo Regency. In addition, the information from by the visited tourists can be more quickly spread with the development of tourism activities by increasing the public infrastructures.

The local government should be leaning towards to the environmentally related policies. Thus, for this study, the Purworejo government has been working on these policies, as they seeks to develop several ecotourism object areas around Jatimalang Beach. The policy analysis is one of the important administrative method in planning and developing the coastal tourism. The policy as the useful activities that must be followed by the subject in handling a certain problem [18]. The ecotourism management must meet al least three criteria, namely providing a countable conservation value, involving the community, and giving the benefit and maintenance for themselves [19]. The tourism subject on Jatimalang Beach has already involved the community, as it can be seen that the community has begun to maintain their own food stalls and their efforts to preserve the environment, although it must be monitored continuously by the government.

4. Conclusion and Recommendation

This study emphasizes on the management of Jatimalang Beach with the sustainable marine ecotourism development by collection the people perception on many aspects, including the beach facilities and infrastructures, ecotourism awareness, and environmental sustainability management. Therefore, the conclusion can be drawn from the analysis that the perception of the coastal area of Jatimalang Beach in Purworejo Regency from the tourists stated that it has a good environmental quality with a beautiful natural scenery. This will provide convenience and relaxing effects for the tourists. However, the facilities around the beaches and also the cleanliness of the coastal area are need to be improved for the sustainable tourism purposes.

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Plastic Waste Recycle for Industrial

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Abstract. The high-income countries are leading to higher consumption of plastic, despite prominent contribution to the global problem of plastic pollution. The high quantities of plastic wastes are extremely threatening to harm the environment and inhabitants due to mismanagement such as ingested in the fish and also harmful to human health (cancer is a major disease) if such consuming a fish. This review paper explored a solution to treating plastic waste to improve the sustainability of the environment. The use of recycled plastic wastes as a component has been found to be the most beneficial as it can be used to replace all solid components.

Keywords: higher consumption of plastic, plastic wastes, recycled plastic wastes

1. Introduction

Urbanization and changing of human lifestyles are major contributors to the high volume of wastes generated and disposed of annually. There are social activities, in product manufacturing and post utilization that create wastes. The number of solid wastes generated increases annually. In contrast, only a limited amount is recycled and landfilled, and a large proportion of rubbish, such as plastic waste (PW are deposited directly or indirectly to the marine environment [1].

One of the solid wastes generated in large quantities and being of high threat to the sustainability of our planet is the plastic wastes. It reported that damage occurs to ecology, economy, and aesthetics when plastic rubbish enters into the ocean [2]. The large quantities of plastic wastes generated all over the world because of its vast application, such as in automotive, manufacturing, packaging, and healthcare [3].

Per capita consumption of plastic continues to increases and remains at a high level in high-income countries [4]. The global plastic production is expected to continually increase from 300 million ton in the 2015 to1800 million ton in 2050 [5].The degradable of plastic wastes ones take a long period depending on the condition to which they are subjected [6], [7]. Consequently, most of PW end up in an environment where they conveyed to the marine environment due to various precipitation phenomena

[8]. The large consumer demands for plastic packaging materials, mostly short-term and single-use materials designed for immediate disposal after use, have resulted in tremendous amounts of PW to be managed for treatment and disposal [9]. While policy-makers have been stimulated to introduce some ideas that help to reduce plastic production and consumption, the perception of different stakeholders must be understood to manage issues relating to plastic production, its wastes, and recycling [8].

2. New challenges in waste management

The effective management of PW requires appropriate identification, collection, separation, storage, transportation, treatment, and disposal, as well as associated critical aspects including disinfection, personnel protection, and training [10]. Plastics have calorific value comparable to conventional fuels (Table 1) [11]. The assumption (e.g., the incentives, taxes, oversimplification on exact a plastic composition, collection system) made during the planning of the waste management system is suddenly no longer fully valid. They justified by the need to achieve levels of collection, recycling, and recovery defined as a political level, which has led to under-sizing of recovery and disposal nor sustainable [12].

Table 1. The calorific value of plastic and the exhaust gas released by incinerating MSW, hazardous waste, and sewage sludge [10]

Type of Plastics	**LHV (MJ/Kg)** [11][a] [13][b]
PE	42-45[a]
PVC	15-25[a]
PA	36.76[b]
PET	21.81[b]
PP	30.90-45[a]
PS	38.97-40[a]
Fines	15[a]
Type	Exhaust gas release (m^3/kt)
MSW	5.5
Hazardous waste	7.0
Sewage sludge	8.0

The PW can be recycled either mechanically, chemically or thermally. However, before the plastic wastes are recycled, they undergo sorting, which is mostly done automatically using technology such as electrostatics, floating, fluorescence, infrared, and spectroscopy. The mechanical recycling of PW involves the physical degradation of waste by using processes such as grinding and/or shredding [14]. The recycling potential of different hard plastic products: high-density polyethylene (HDPE), polyethylene terephthalate (PET), polypropylene (PP), polystyrene (PS), and polyvinyl chloride (PVC) is presented in Fig.2. HDPE, LDPE, PET, PP, PS, and PVC are commonly used plastic resins in packaging applications for a variety of products, including bottles and tubes, pack and cups, trays, bags, caps, bubble wrapping and films, containers, and many others [5]. The sorting and reprocessing potential of plastics in this category is above 50%. However, PET, out of all the plastic types, exhibits a low recycling potential. It can be deduced that PET may be more suitable for other applications than recycling [15]. A summary of the types of plastic wastes is presented in Fig. 1. Most PW is composed of LDPE. However, the presence of HDPE and PP is also significant and similar to that of HDPE. Table 2 shows the mechanical properties of the construction application of recycled plastic types.

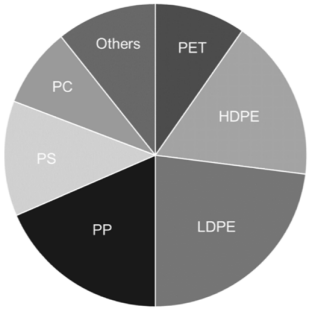

Figure 1. Plastic wastes composition [1]

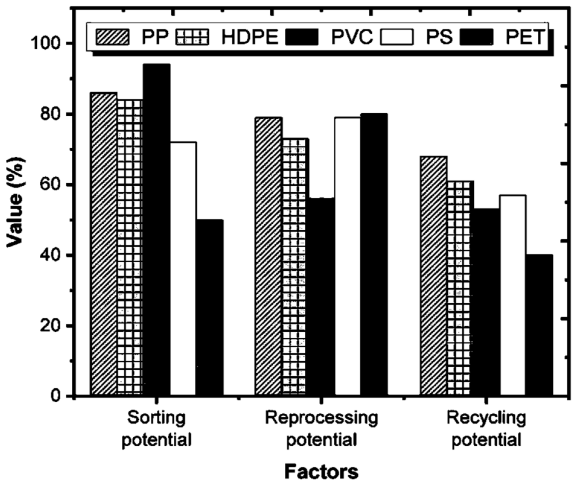

Figure 2. Comparison of sorting, reprocessing, and recycling potentials of various plastics [15]

Table 2. Mechanical Properties construction application of recycled plastic types [1].

Plastic composition	Mechanical Properties	Possible construction application
HDPE	Rigid	Plastic lumber, table, chairs
LDPE	Flexible	Brick and block
PP	Hard and flexible	Aggregates in asphalt mixture
PS	Hard and brittle	Insulation material
PET	Hard and flexible	Fibers in cementitious composites
PC	Hard and rigid	Aggregates in cementitious composites

The utilization of PW in the manufactory of another material is a partial solution environmental that will reduce the proportion of PW incineration of landfills. The enviromental and economic performance of different PW management approaches is presented in Fig.3. Pyrolysis and gasification are in development, stimulated by the request of a more sustainable wastes treatment option [12]. An economic assessment proposes the present scenario is sustained by a tipping fee that is continuously rising due to the high costs of transportation toward the treatment processes, both those for recovery as well as those for disposal [16]. The development and production of PMC (polymer matrix composite) using nature reinforcement and PW are a promising solution for recycling the waste and utilization of such waste as a renewable source for beneficial use [17].

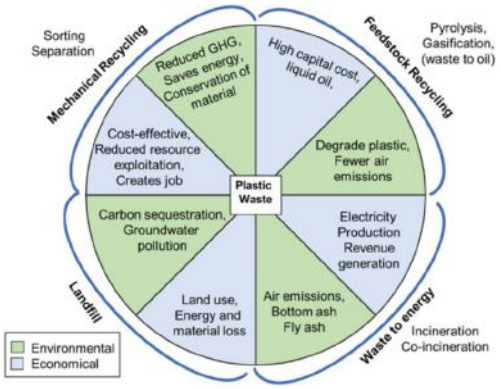

Figure 3. Enviromental and economic performance of various PW management approaches [12]

3. Limitations and the potential revenue generation of plastic waste application

Products of PW recycled have limitations and the potential revenue generation [1]. Some of the major limitation associated with the use of PW for construction applications such as harvesting(PW are contaminated with various types of plastic and another material), varying composition (PW are made up from different grades and types of plastic which might result in a non-isotropic performance), Low-density (unsuitable in application where high toughness and elasticity modulus), lack of understanding (the long-term performance has limited), low surface energy (poor mechanical bonding can lead to a reduction of the mechanical properties), and lack of standards (no standard that supports the use of PW for construction)

The potential revenue generation as a result of using PW: lower cost, reduction in waste management, value addition, lower transportation cost, and reduction in energy cost.

4. Conclusion

Plastic wastes are inevitable. Therefore, plastic wastes recycling plays a significant role in improving the sustainability of the environment. The use of PW for many application support the sustainability trend of a circular economy. The PW recycle products can replace all components, with somewhat acceptable detrimental effects on the performance of the products.

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Prediction of $4f^7$-$4f^65d^1$ transition energy of Eu^{2+} in oxides based on first-principles calculations and machine learning

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Abstract. In order to establish a method to predict the $4f^7$-$4f^65d^1$ transition energy of Eu^{2+} in oxides, linear regression models were created based on first-principles calculations and machine learning. The model clusters consisting of the central Eu^{2+} and O^{2-} ions closer than the nearest cation were constructed and the $4f^7$-$4f^65d^1$ absorption energy of Eu^{2+} in these clusters were calculated by first-principles many-electron calculation using the relativistic discrete variational multi-electron (DVME) method. However, the $4f^7$-$4f^65d^1$ absorption energies of Eu^{2+} in oxides calculated by relatively simple first-principles calculations tend to be overestimated by ca. 1.6 eV. In order to improve the accuracy of the prediction, we performed machine learning considering the calculated absorption energy as well as the other electronic and structural parameters as the attributes. As a result, the regression formula to predict the $4f^7$-$4f^65d^1$ absorption energy of Eu^{2+} in oxides has been created by machine learning. The $4f^7$-$4f^65d^1$ absorption energy predicted by this model are in good agreement with the experimental ones. Therefore, accuracy of the prediction was significantly improved compared to the simple first-principles calculations. In a similar way, a predictive model of the $4f^65d^1$-$4f^7$ emission energy of Eu^{2+} in oxides has been also created.

1. Introduction

The $4f^7$-$4f^65d^1$ transition energy of Eu^{2+} in oxides are utilized as phosphors for cathode-ray tube, fluorescent lamp, white light emitting diode (WLED) [1]. For theoretical design of novel phosphors based on Eu-doped oxides, it is indispensable to predict $4f^7$-$4f^65d^1$ transition energy of fictitious materials. At first, we calculated the $4f^7$-$4f^65d^1$ absorption energy by relatively simple first-principles calculations. However, the calculated values tend to be overestimated by ca. 1.6 eV compared to the experimental values. Although the accuracy of the prediction can be improved by performing more sophisticated calculations considering larger model clusters, structural optimization, and so on, such calculations are computationally expensive. Recently, the machine learning technique has been drawing attention as an efficient approach for materials discovery and design [2]. Therefore, we tried to improve the accuracy of the prediction of the $4f^7$-$4f^65d^1$ absorption energy by creating a machine learning model considering the calculated $4f^7$-$4f^65d^1$ absorption energy as well as the other electronic and structural parameters as the attributes. In this work, in addition to the predictive model of the $4f^7$-$4f^65d^1$ absorption energy, the predictive model for the $4f^65d^1$-$4f^7$ emission energy was also created.

2. Computational Methods

2.1. First-principles calculation

We performed the first-principles calculations of the $4f^7$-$4f^65d^1$ absorption energy using the relativistic discrete variational multi-electron (DVME) method [3]. We considered 26 oxide crystals and constructed the corresponding model clusters consisting of the doped Eu^{2+} ion and the first-neighbor O^{2-} ions based on the crystal structure data [5-29]. Table 1 shows the oxides and the model clusters considered in this work. The four component relativistic molecular orbitals (MOs) were obtained by performing the MO calculations using the discrete-variational Xα (DV-Xα) method [4]. Then the multiplet energies in the $4f^7$ and $4f^65d^1$ configurations were obtained by performing the configuration interaction (CI) calculations using the relativistic DVME method. The theoretical $4f^7$-$4f^65d^1$ absorption energy was estimated as the energy of the lowest level mainly composed of $4f^65d^1$ configuration relative to the lowest level mainly composed of $4f^7$ configuration.

2.2. Machine learning

We used the machine learning software called WEKA (Waikato Environment for Knowledge Analysis) which was developed in the University of Waikato [30]. For the creation of the predictive model of $4f^7$-$4f^65d^1$ transition energy based on the electronic and structural parameters, the linear regression (single layer perceptron) model was adopted. We considered the following 7 attributes: (1) calculated $4f^7$-$4f^65d^1$ absorption energy, (2) net charge of Eu^{2+}, (3) bond order between Eu and O, (4) barycentre of 5d levels relative to the lowest 4f level, (5) crystal field splitting of 5d levels, (6) average bond length, (7) valence of the substituted cation.

3. Results and discussion

3.1. Predictive model of $4f^7$-$4f^65d^1$ absorption energies

The experimental $4f^7$-$4f^65d^1$ absorption energies in Table 1 [1] were used as the training data for machine learning. Since excessive number of attributes usually results in poor generalization ability, we tried to create a predictive model with as little attributes as possible. By creating predictive models considering the calculated $4f^7$-$4f^65d^1$ absorption energies and two additional parameters as the attributes and comparing the results, we obtained the following predictive model,

$$E = 0.6050E^{calc} - 0.8775Q + 0.7174V - 0.0924, \quad (1)$$

where E^{calc} is the calculated $4f^7$-$4f^65d^1$ absorption energy, Q the net charge of Eu^{2+}, and V the valence of the substituted cation.

Figure 1 shows the correlation between the $4f^7$-$4f^65d^1$ absorption energies calculated by the simple DVME calculations and the experimental ones. The correlation coefficient was 0.8042 and the calculated values are overestimated by ca. 1.6 eV. Figure 2 shows the correlation between the $4f^7$-$4f^65d^1$ absorption energies predicted by eq. (1) and the experimental ones. The correlation coefficient was 0.9142. Therefore, the accuracy of the prediction of $4f^7$-$4f^65d^1$ absorption energy was significantly improved by net charge of Eu^{2+} and valence of the substituted cation.

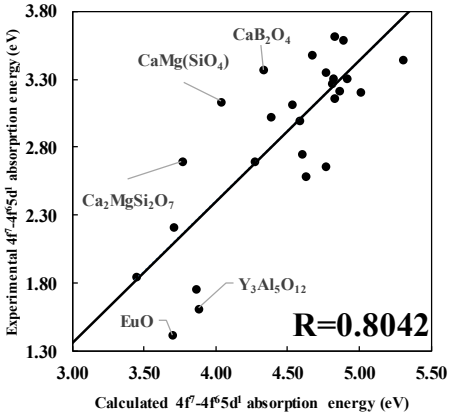

Figure 1. Correlation between the $4f^7$-$4f^65d^1$ absorption energies calculated by first-principles calculations and experimental ones.

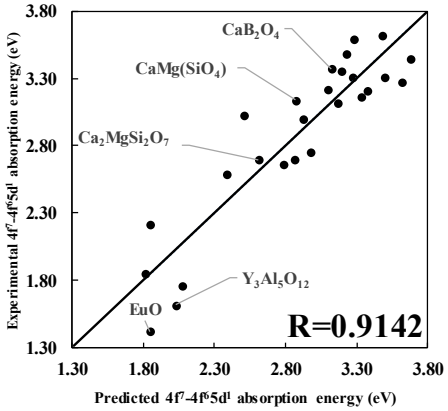

Figure 2. Correlation between the predicted $4f^7$-$4f^65d^1$ absorption energies by eq. (1) and experimental ones.

Table 1. Comparison between the $4f^7$-$4f^65d^1$ absorption energies predicted by the machine learning model of eq. (1) and experimental ones.

Crystal		Substituted ion	Model cluster	Predicted (eV)	Experimental (eV)	Deference (eV)
$SrSO_4$	[5]	Sr	EuO_{12}^{22-}	3.48	3.62 [1]	-0.14
$CaSO_4$	[6]	Ca	EuO_8^{14-}	3.62	3.27 [1]	0.35
$BaBe_2(BO_3)_2$	[7]	Ba	EuO_{12}^{22-}	3.28	3.60 [1]	-0.32
$KBaPO_4$	[8]	Ba	EuO_9^{16-}	3.38	3.21 [1]	0.16
$KSrPO_4$	[9]	Sr	EuO_9^{16-}	3.34	3.16 [1]	0.18
BaB_8O_{13}	[10]	Ba	EuO_{10}^{18-}	3.68	3.45 [1]	0.23
SrB_4O_7	[11]	Sr	EuO_8^{14-}	3.23	3.48 [1]	-0.25
$Ba_2LiB_5O_{10}$	[12]	Ba	EuO_8^{14-}	3.27	3.31 [1]	-0.04
CaB_2O_4	[13]	Ca	EuO_8^{14-}	3.12	3.37 [1]	-0.25
$Ba_2Mg(BO_3)_2$	[14]	Ba	EuO_9^{16-}	2.93	3.00 [1]	-0.07
$SrAl_2B_2O_7$	[15]	Sr	EuO_6^{10-}	3.17	3.12 [1]	0.05
$CaBPO_5$	[16]	Ca	EuO_{10}^{18-}	3.50	3.31 [1]	0.19
$Ba_2MgSi_2O_7$	[17]	Ba	EuO_8^{14-}	2.98	2.76 [1]	0.22
$Sr_2MgSi_2O_7$	[18]	Sr	EuO_8^{14-}	2.86	2.70 [1]	0.16
$Ca_2MgSi_2O_7$	[19]	Ca	EuO_8^{14-}	2.61	2.70 [1]	-0.09
$BaAl_2(SiO_4)_2$	[20]	Ba	EuO_{12}^{22-}	3.20	3.35 [1]	-0.15
$Li_4Sr_2Ca(SiO_4)_2$	[21]	Ca	EuO_8^{14-}	3.10	3.22 [1]	-0.12
$CaB(OH)(SiO_4)$	[22]	Ca	EuO_8^{14-}	2.51	3.03 [1]	-0.52
$CaMg(SiO_4)$	[23]	Ca	EuO_6^{10-}	2.87	3.14 [1]	-0.27
$EuAlO_3$	[24]	Eu	EuO_{10}^{18-}	2.39	2.95 [1]	-0.56
$Y_3Al_5O_{12}$	[25]	Y	EuO_8^{14-}	2.03	1.62 [1]	0.41
$Lu_3Al_5O_{12}$	[26]	Lu	EuO_8^{14-}	2.08	1.76 [1]	0.32
$BaZrO_3$	[27]	Ba	EuO_6^{10-}	2.78	2.67 [1]	0.11
SrO	[28]	Sr	EuO_6^{10-}	1.85	2.21 [1]	-0.36
EuO	[29]	Eu	EuO_6^{10-}	1.85	1.43 [1]	0.42
CaO	[28]	Ca	EuO_6^{10-}	1.81	1.85 [1]	-0.04

The generalization ability of this model was evaluated by the cross-validation method [30]. The correlation coefficient by the leave-one-out method was 0.8592. Therefore, this model has higher accuracy and reasonable generalization ability.

Table 1 shows the predicted $4f^7$-$4f^65d^1$ absorption energies based on this machine learning model. The difference between the predicted and experimental values are within 0.56 eV, indicating that the absolute values of the $4f^7$-$4f^65d^1$ absorption energies are reasonably predicted.

3.2. Predictive model of $4f^65d^1$-$4f^7$ emission energies

The predictive model of the $4f^65d^1$-$4f^7$ emission energies was also created in a similar way. The experimental $4f^65d^1$-$4f^7$ emission energies in Table 2 [1] were used as the training data for machine learning. We also tried to create a predictive model with as little attributes as possible. By creating predictive models considering the calculated $4f^7$-$4f^65d^1$ absorption energies and one additional parameter as the attributes and comparing the results, we obtained the following predictive model,

$$E = 0.5305E^{calc} - 0.5855Q - 0.7546, \quad (2)$$

where E^{calc} is the calculated $4f^7$-$4f^65d^1$ absorption energies and Q the net charge of Eu^{2+}.

Figure 3 shows the correlation between the $4f^7$-$4f^65d^1$ absorption energies calculated by the simple DVME calculations and the experimental $4f^65d^1$-$4f^7$ emission energies. The correlation coefficient was 0.8481. Figure 4 shows the correlation between the predicted and experimental $4f^65d^1$-$4f^7$ emission energies. The correlation coefficient was 0.9050 and correlation coefficient of leave one out method was 0.8795. Therefore, this predictive model has higher accuracy and reasonable generalization ability.

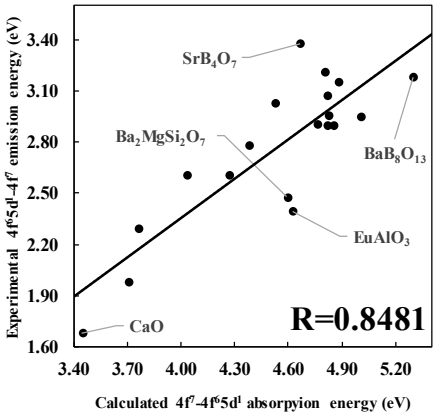

Figure 3. Correlation between the $4f^7$-$4f^65d^1$ absorption energies calculated by first-principles calculations and the experimental $4f^65d^1$-$4f^7$ emission energies.

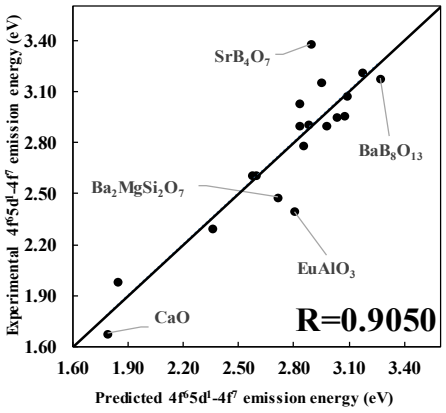

Figure 4. Correlation between the predicted $4f^65d^1$-$4f^7$ emission energies by eq. (2) and experimental ones.

Table 2. Comparison between the $4f^6 5d^1$-$4f^7$ emission energies predicted by the machine learning model of eq. (2) and experimental ones.

Crystal		Substituted ion	Model cluster	Predicted (eV)	Experimental (eV)	Deference (eV)
$SrSO_4$	[5]	Sr	EuO_{12}^{22-}	3.07	2.96 [1]	0.11
$CaSO_4$	[6]	Ca	EuO_8^{14-}	3.17	3.21 [1]	-0.04
$BaBe_2(BO_3)_2$	[7]	Ba	EuO_{12}^{22-}	2.95	3.16 [1]	-0.21
$KBaPO_4$	[8]	Ba	EuO_9^{16-}	3.03	2.95 [1]	0.08
$KSrPO_4$	[9]	Sr	EuO_9^{16-}	2.98	2.90 [1]	0.08
BaB_8O_{13}	[10]	Ba	EuO_{10}^{18-}	3.27	3.18 [1]	0.09
SrB_4O_7	[11]	Sr	EuO_8^{14-}	2.89	3.38 [1]	-0.49
$SrAl_2B2O_7$	[14]	Sr	EuO_6^{10-}	2.83	3.03 [1]	-0.20
$CaBPO_5$	[16]	Ca	EuO_{10}^{18-}	3.09	3.08 [1]	0.01
$Ba_2MgSi_2O_7$	[17]	Ba	EuO_8^{14-}	2.71	2.48 [1]	0.23
$Sr_2MgSi_2O_7$	[18]	Sr	EuO_8^{14-}	2.59	2.61 [1]	-0.02
$Ca_2MgSi_2O_7$	[19]	Ca	EuO_8^{14-}	2.36	3.30 [1]	0.06
$BaAl_2(SiO_4)_2$	[20]	Ba	EuO_{12}^{22-}	2.88	2.90 [1]	-0.02
$Li_4Sr_2Ca(SiO_4)_2$	[21]	Ca	EuO_8^{14-}	2.83	2.90 [1]	-0.07
$CaB(OH)(SiO_4)$	[22]	Ca	EuO_8^{14-}	2.85	2.78 [1]	0.07
$CaMg(SiO_4)$	[23]	Ca	EuO_6^{10-}	2.57	2.61 [1]	-0.04
$EuAlO_3$	[24]	Eu	EuO_{10}^{18-}	2.80	2.39 [1]	0.41
SrO	[28]	Sr	EuO_6^{10-}	1.84	1.98 [1]	-0.14
CaO	[28]	Ca	EuO_6^{10-}	1.79	1.68 [1]	0.11

Table 2 shows the predicted values of the $4f^6 5d^1$-$4f^7$ emission energies based on this machine learning model. The difference between the predicted and experimental values are within 0.49 eV, indicating that the absolute values of the $4f^6 5d^1$-$4f^7$ emission energies are reasonably predicted.

4. **Conclusion**

By considering the $4f^7$-$4f^6 5d^1$ absorption energy obtained by the first-principles calculation as one of the attributes, we performed machine learning and created the predictive model of the $4f^7$-$4f^6 5d^1$ absorption energy of Eu^{2+} in oxide crystals. As a result, we successfully created the predictive model of the $4f^7$-$4f^6 5d^1$ absorption energy using the calculated $4f^7$-$4f^6 5d^1$ absorption energy, the net charge of Eu^{2+}, and the valence of the substituted cation as the attributes. In a similar way, we also created the predictive model of the $4f^6 5d^1$-$4f^7$ emission energy considering the calculated $4f^7$-$4f^6 5d^1$ absorption energy and the net charge of Eu^{2+} as the attributes. The predicted values are in reasonable agreement with the experimental ones in both models.

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