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The Impact of Farm Field Trip on Student Practices to Manage Waste of Coffee Industry

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Abstract: Chemistry learning requires an appropriate and varied learning method to facilitate the delivery of material and create a pleasant learning atmosphere. The delivery of material that is easy to understand and a pleasant atmosphere will impact maximum learning outcomes. The field trip method is a learning method outside the classroom, where students are invited to a location. By visiting the location directly related to the subject matter, it is hoped that students will better understand and get a real picture of the material being studied. This study aims to improve student competence to solve problems in waste of coffee farm in Cibuleo, Puncak, Indonesia. The coffee industry is one of the agro-industry which produces waste in the production process. Students learn about problems related to solid and liquid waste from the visit to the coffee farm. The problem of waste problems found in coffee farms has resulted in various science projects that will be carried out in the laboratory. Students' project science is evaluated based on the suitability of the title with the problem, problem-solving, experimental design, results, presentation, and answer to questions. The evaluation results indicate that the highest scores were derived from presentation (4.5) and problem-solving (4.40) components. The lowest scores were derived from problem and answer to question (4.25) components.

Keywords: field trip, waste of coffee industry, project science, evaluation.

农田考察对学生管理咖啡业浪费的实践的影响

摘要：化学学习需要一种适当且多样化的学习方法，以促进材料的传递并营造愉快的学习氛围。易于理解且气氛宜人的材料的交付将影响最大的学习成果。实地考察方法是在教室外面的一种学习方法，在该方法中，学生被邀请到某个位置。希望通过访问与主题直接相关的位置，希望学生能够更好地理解并获得所研究材料的真实图片。这项研究旨在提高学生的能力，以解决印度尼西亚蓬查克洋葱的咖啡农场浪费中的问题。咖啡工业是在生产过程中产生废物的农业工业之一。通过参观咖啡农场，学生将了解与固体和液体废物有关的问题。在咖啡农场中发现的废物问题已经导致了将在实验室中进行的各种科学项目。根据题名与问题，问题解决，实验设计，结果，演示文稿和答案的适合性，评估学生的项目科学。评估结果表明，最高分来自演示（4.5）和解决问题（4.40）组件。最低分数来自问题和对问题的回答（4.25）。

关键词：实地考察，咖啡行业的浪费，项目科学，评估。

1. Introduction

The field trip is one learning method that takes students to a place away, off class, which is relevant to

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learning materials. Field trips to museums, zoos, and science centers or the natural environment could deepen students' understanding of subjects usually taught in the classroom [10, 20]. Wang and Carlson [21] pointed out that "A field trip is a common strategy used by educators to bring out-of-school learning experience into schools". Batic [4] explained that "Education field trip enables pupils to gain new experience and make them more aware of the world in which they live". It has been proven that significant cognitive learning can and does occur on science field trips. The information is not immediately forgotten and may be remembered for a long time [11]. A key benefit in field trip learning is the transfer of knowledge between students. Students with prior experiences share their knowledge with other students, and the experiences serve to connect the group [8].

The field trip learning method can improve abilities in cognitive, psychomotor aspects [17]. It promotes: (i) critical and creative thinking skills, (ii) interpersonal skill, and self-confidence [5]; improves academic achievement [7]; enhances knowledge of art and culture; gives inspiration, motivation, and creativity to create the art [22]; and creates effective and efficient learning [1].

Green et al. [9] surveyed 101,912 students and 489 teachers coming from 123 schools. Findings showed that students participating in a museum field trip could explain the paintings of their interest in details rather than those of a control group.

A survey on high school students' laboratory field trips in numerous universities aiming to improve students' knowledge of continued issues has been conducted by Katherine et al. [12]. It resulted that students' interests in science and confidence have increased while their interests in science and career in science have decreased.

Students' existing misconception about wetland could be resolved by making a field trip. Before participating in the field trip, students' conception of a wetland referred to a place that was dirty, unhealthy, and hazardous for health. Indeed, this has changed following the field trip to the wetland. They learned that wetland is an ecological system in which many kinds of animals live, i.e., birds, cows, plants, and clean water resources are found [18].

Understanding a concept can be well-developed when the students are directly involved in the concept learned in class [1]. Stacy et al. and Palmer [15] reported that a field trip to a farm and plantation allows children to promote their knowledge of the concept of vegetables and fruit. Dewit & Storksdieck [6] also noted that out-of-class learning could sharpen students' cognitive and affective abilities. Anderson & Krathwohl [3] declared that understanding a concept in the cognitive realm is shown in such abilities as interpreting, exemplifying, classifying, summarizing, inferring, comparing, and explanation.

Orion & Holfstein [14] elaborated that a learning process can succeed provided that the field trip is to be correlated with the class curriculum. The field trip integrated with the curriculum has been a learning method to help students improve their understanding of natural phenomena. It enables students to interact with nature [16] directly. Sriarunrasmee *et al*. [19] stated that field trips could improve understanding of a scientific concept, inquiry process, and students' critical thinking. This is also strengthened with Kiesel's [13] findings noting that field trip activity may identify students' cognitive ability. Field trip builds students' knowledge of electricity and magnet by utilizing their experience during the field trip at a science museum. Anderson *et al*. [2] proved that students develop and reconstruct the knowledge into a new concept having the field trip. This research aims to enhance the Chemistry students' conceptual understanding to solve problems found in the waste of the coffee industry.

2. Method

2.1. Equipment and Materials Required

Required materials: dried and powdered coffee skin, wastewater of processed coffee fruit to coffee bean, Aquadest, NADES solvent, seed *Vigna unguiculata*.

Required equipment: jar test, pyrolisator, vermireactor, balance, and glassware.

2.2. Field Trip

The three-day field trip was conducted at Cibulao, Puncak, a coffee plantation that ranges 100 km away from campus (Jakarta). Students began the day by watching a video describing activities taking place at the coffee plant. Next, they were having a discussion, making a list of problems they would learn during the visit. Based on the result of the discussion, the students were divided into groups according to the problems they would address. Each group, along with its field counselor, was heading to the determined object. The students were on the spot observing, recording, interviewing the farmers, and taking samples when necessary. Having had the visit to the coffee plant, all the students went back to the camp, had lunch, and went back home to Jakarta. It is expected that, after the field trip, the students will be able to observe and classify problems in relation to coffee waste and devise a project to be conducted in the laboratory.

2.3. Laboratory Experiment

All projects were conducted in the Chemistry Laboratory of Universitas Negeri Jakarta under the supervision of the adviser. The students made a hand-out of the work procedure approved by the instructor (master student) prior to starting the project. The laboratory assistant prepared the equipment and materials needed, and the students were guided by an instructor. The science project conducted was the utilization of solid waste for vermicompost, biochar, tannin, activated carbon, and wastewater processing by means of coagulation.

2.4. Procedure

2.4.1. Coffee Processing Wastewater Treatment by Coagulation

Coffee wastewater was processed using a jar test. 1 litre of wastewater was poured into a beaker and 1 gram of tannin was then added. The jar test was operated with rapid mixing at a speed of 160 rpm for one minute, and slow mixing afterwards at a speed of 60 rpm for 10 minutes. After the flocculation had been completed, the jar test was turned off, the gang stirrer was removed, and the solution was set aside for 10 minutes until its constituents were perfectly sedimented. The pure water in each beaker was removed and analysed for its pH value, total dissolved solid (TDS), turbidity, DO, COD, and BOD.

2.4.2. Preparation of Vermicompost

2 kg of respective compost, twigs, coffee skin, the constituents of the wastewater process, and dried cow manure were placed in a box of dimensions 60 x 30 x 19 cm. 200 earthworms and red worms were added to the box to note what would happen to the worms in two days. If the worms remained healthy and agile, the media had been properly used. If the worms roamed over or escaped from the media, the media had not been suitable for the worms. This could be maintained by watering the media to keep it humid. In the fourth day, the vermicompost was formed. Next, it was removed by using a trowel, stored in a container, and labelled. The N, P, K, Ca, Mg, and Zn contents in the vermicompost were then analyzed by means of the titration method.

Vermicompost to improve growth of Vigna unguiculata: Prepare four 300 mL plastic cups filled with soil and put 5%, 10%, 15%, and 20% of vermicompost into each cup. Stir them up, and set them aside for 2 weeks. Then put *Vigna unguiculata* seeds into the cups, and observe the growth of the coffee seeds for 4 weeks. Note down the height, number of leaves, and plant weight.

2.4.3. Preparation of Biochar

Biochar was produced by using a pyrolisator. The coffee husks, twigs, and leaves were dried and ground to 1–2 cm and were put into the pyrolisator. Afterwards, they were roasted at a temperature of 450^0C. When cold, the formed biochar was taken out, stored in a bottle, and labelled.

Remediation of polluted soil by ion chromium using biochar: Prepare four 10 kg polybags. Fill them up with soil and put 50 mg ion Cr^{+6} into each of them. Stir it up, and set it aside for one week. Next, add 5%, 10%, 15%, and 20% mg of biochar into each polybag. Stir it up, and set it aside for one week. Heights of plants were measured, and the numbers of leaf counted 15, 30, and 45 days after transplanting.

2.4.4. Extraction of Tannin

Tannin was extracted from SCG and fed to the NADES solvent at a ratio of 1:10g/mL. Microwave power was adjusted to 200W for 8 minutes. The extracts were analyzed using UV-Vis spectrophotometer. Yield was counted using the following equation:

$$\text{Yield of tannin} = \frac{\text{Weight tannin}}{\text{Weight SCG}} \times 100\%$$

Synthesis of natural deep eutectic solvent: NADES was prepared with mixed choline chloride (ChCl) and glucose with a ratio of 1:2 and heated at 80°C with constant stirring in a water bath until a clear, homogeneous liquid was formed.

2.4.5. Preparation of Activated Carbon (AC) from SCG

SCG was dried at 105°C for 12 hours and carbonized at 500°C for 30 minutes in a muffle furnace. Carbon SCG was immersed for 24 hours in a 20% $ZnCl_2$ solution with a ratio of 1:3 and then washed with aquadest and dried at 105^0C for 4 hours and characterized by SEM EDX.

Adsorption of direct black 38 with activated carbon: Activated carbon SCG was evaluated as an adsorbent for the removal of methylene blue (MB) from aqueous solution. Batch adsorption tests were performed at 25°C, and the effects of initial concentration, contact time, adsorbent dosage, and pH were investigated.

On a 100 mL beaker glass, 10 mg of AC was mixed with 50 mL of *direct black* 38 solutions and stirred for 60 minutes with magnetic stirrer at 4000 rpm. After equilibrium, the adsorbent was filtered with a Whatman filter, and concentrations of dye were determined with a UV-VIS spectrophotometer (Shimadzu 1600 A) at the maximum absorbance wavelengths of tested dyes. % adsorbed direct black 38 is calculated by the equation:

$$\%\text{adsorbed} = \frac{Co-Ct}{Co} \times 100\%$$

where Co= initial concentration and Ct equilibrium concentration.

2.4.6. Evaluation

The project of the coffee waste problem was evaluated based on ability to explain: problem, problem-solving, product benefit, design of experiment, results, the cognitive component, and presentation.

3. Result and Discussion

The field trip results showed that various kinds of waste existed, and based on the discussion, a science project was set to solve this waste problem. The topic, process, product to be the project were elaborated in detail, as illustrated in Table 1.

Table 1 Method of treatment waste coffee industry

No	Waste coffee	Laboratory topic	Method
1	Wastewater	Water purification	coagulation
2	Coffee pulp	Organic fertilizer	Vermitechnology
3	Coffee husk	Soil remediation	Pyrolysis
4	Spent coffee ground	Biocoagulant	Extraction
5	Coffee skin	Adsorbent	Carbonization

3.1. Laboratory Experiment

Based on the topic of the project shown in Table 1, the students formulated a more measurable research topic. The research topic approved by the advisor was taken into action in the laboratory.

Table 2 Research title for the project-based learning

No	Research Topic
1	Microwave-assisted extraction of tannin from the spent coffee ground with NADES solvents
2	Green technology for treatment coffee processing wastewater using biocoagulant Tannin
3	The effects of biochar on remediation of chromium (Cr) in soil and plant growth *Aeschynanthus radiacans*
4	Vermicoposting of coffee industry waste: effects on the *Vigan unguiculata growth*
5	Utilization of carbon from coffee skin waste for adsorption Methyl Orange

3.2. Result of Experiment

3.2.1. Extract Tannin from SCG with NADES Solution

The result showed the highest yield of tannin 35.60 mg/g at 200 W and 8 minutes extraction time using chlolime: glucose with ratio 1:2 mol and 20% water.

3.2.2. Coagulation Wastewater Coffee Industry Using Tannin

Furthermore, the extract with the highest yield of tannins is used as the biocoagulant. The effect of dose tannin on COD, BOD, turbidity, and BOD showed that the coagulation of wastewater could reduce the content of COD to 89%, turbidity to 76%, total dissolve solid to 79%.

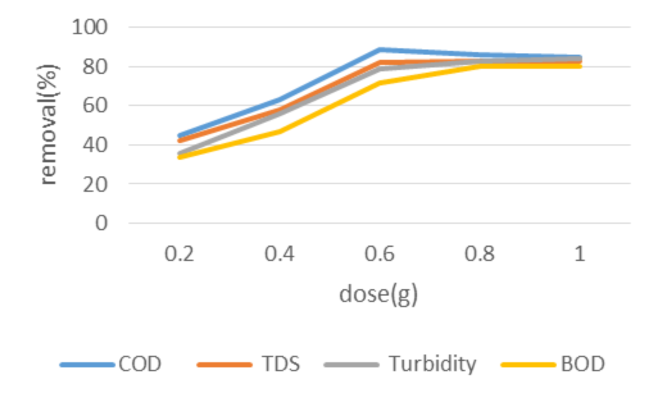

Fig. 1 Effect of dose tannin on removal COD, BOD, TDS, and turbidity

3.2.3. The Effects of Biochar on Remediation of Cadmium in Soil and Plant Growth Aeschynanthus Radicans

FTIR spectra of biochar coffee husk are shown in Fig. 2.

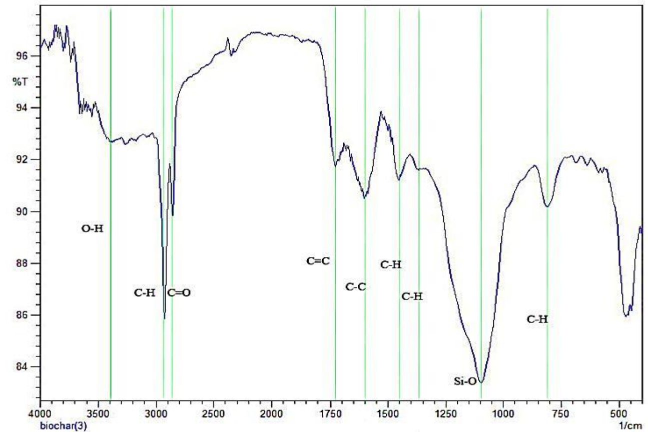

Fig. 2 FTIR spectra of biochar coffee husk

Spectra analysis of biochar shows a peak at 3352.28 cm^{-1} which is identified as stretching O-H obtained by minerals with hydroxyl groups. This hydroxyl group will decrease in intensity with heating temperature. From the results of the fingerprint area on the IR spectra (1500-500 cm^{-1}), large amounts of silicon dioxide in the form of silicates and polymorphic silica are indicated by the appearance of the dominant O-Si-O stretching peak at 1090 cm^{-1}. Among them are the 800 cm^{-1}, 948 cm^{-1}, 1190 cm^{-1}, 1640 cm^{-1}, 3330 cm^{-1}. Typical IR spectra showing biochar aromaticity were seen in 1595.13 cm^{-1}.

The addition of biochar in soil significantly increased the soil reaction (pH), organic matter (OM), and nutrient content of nitrogen, phosphorus, and potassium (N, P, and K). The phytotoxicity test revealed that biochar significantly increased *Aeschynanthus radicans* height and number of leaves. Fig. 3 shows the effect of biochar on leaf height and number. The results showed that the addition of 20% biochar/polybag could increase plant height two times higher than 5% biochar/polybag.

(a) (b) (c)

Fig. 3 The effect of biochar on height and number of leaves *Aeschynanthus radicans*: Soil with (a) 5% biochar, (b) 10% biochar, and (c) 20% biochar

3.2.4. Vermicomposting of Coffee Industry Waste: Effects on Vigna Unguiculata Growth

The results showed that the application of vermicompost to the growing media had a significant effect on the growth of plant height, number of leaves, leaf area, and number of plant branches. The planting media containing 20% of vermicompost produced the best growth.

Fig. 4 (a) Soil with 20% vermicompost, (b) soil with 10% vermicompost, (c) soil with 15% vermicompost

3.2.5. Use of Activated Carbon from Coffee Skin Waste for Adsorption (Methyl Orange)

Fig. 5 shows the SEM carbon-active SCG. This figure demonstrates the activated carbon from the SCG has mesoporous and microporous structures, with sizes of 10µm and larger. The EDX results in Fig. 6 show that SCG-activated carbon contains 89.88% C, 9.38% O, 0.32% Si, and 0.42%, Ca where Si and Ca are impurities within activated carbon.

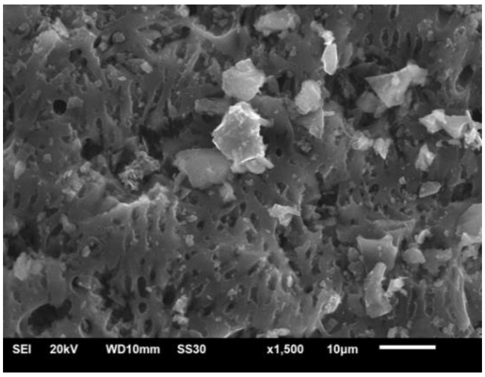

Fig. 5 SEM micrographs of activated carbon

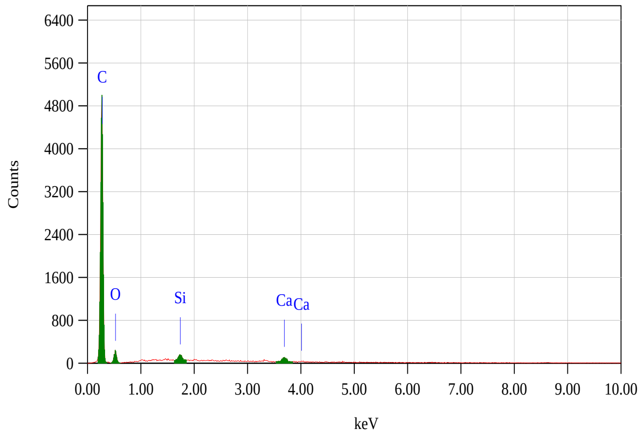

Fig. 6 EDX of activated carbon

3.2.6. Adsorption Methyl Orange (MO) with Activated Carbon

The effect of a concentration of MO dye was investigated in 20 mL of different dye concentrations ranging from 5 to 30 mg/L within 1000 mg of growth material containing 500 mg of carbon active. The highest efficiencies of the removal of MO were 88% at 10 mg/L using 500 mg of dose-activated carbon. The removal seemed to be decrease as the initial concentration of MO increased.

The effect of contact time (at intervals of 10 minutes over the course of an hour) on the removal of MO at 10 mg/L of dye solution of 50 mL of growth material with 500 mg of activated carbon, showed that during MO-removal by activated carbon, SCG increases with increased contact time from ten to forty minutes. When the contact time was increased to 50 minutes, MB removal decreased to 80%, as shown in Fig. 7.

The influence of pH on MO removal was studied at pH 2, pH 4, pH 6 and pH 8 of 50 mg/L MO solution as shown in Fig. 8. The MO became colorless at pH 4. The MO removal studies revealed that the highest removal efficiency for MO (85%) took place at pH 4.

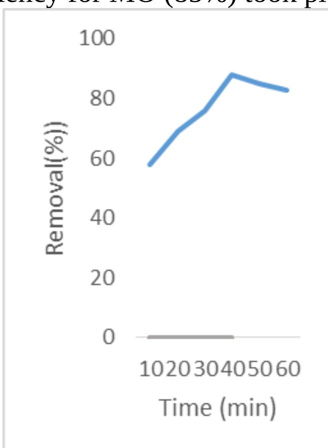

Fig. 7 Effect of contact time on removal MO

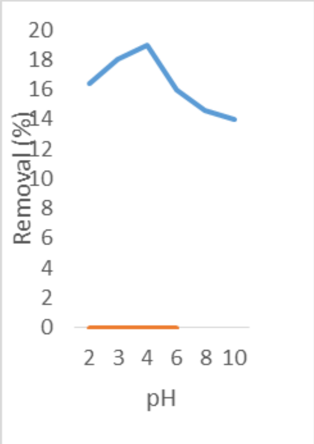

Fig. 8 Effect of pH on removal MO

3.3. Evaluation

Based on the project shown in Table 1, the students formulated a more measurable research topic. The research topic approved by the advisor was subsequently conducted in the laboratory and the resulting evaluation is shown in Table 4.

Table 4 The average score of the science project report (n= 7)

No	Component	Score
1	Problem	4.25
2	Solving Problem	4.40
3	Experimental design	4.30
4	Results	4.30
5	Presentation	4.50
6	Answer question	4.25

The data in Table 4 indicates that the highest scores were derived from the cognitive (4.50) and problem-solving (4.40) components; the lowest scores were derived from problem and answer components (4.25). Similar results were reported by Heike and Franz [10], who found that students' cognitive ability was improved by engaging in field trips.

Before participating in a field trip, students were unable to formulate problems with simple and communicative language. However, when they saw a real problem taking place in the environment, they obviously found it easy to explain the problem and to solve it at the same time. As a result, the students could successfully apply a scientific method and undertake science projects that were relevant to the problems they observed.

The students undertaking the field trip showed significant improvement in their cognitive knowledge, from formulating a problem, problem solving, and designing an experiment, to communicating the results of the experiment to the advisor. The students on this field trip were guided to observe, ask questions about the problems facing farmers and society, identify waste problems, and seek proper ways to find solutions. They had to prepare relevant questions, formulate a hypothesis, design their own method, collect and analyze data, and reach conclusions with their colleagues, as scientists do.

Most importantly, despite the project's unpromising results due to several groups' lack of experience, most students were able to transfer their knowledge and ideas to the community, as proven in the interviews.

The results of the study show that students were able to apply their acquired knowledge to help solve problems in their communities.

4. Conclusion

Field trip-based learning to solve waste problems in farming has evidently improved the students' scientific investigations. The field trip helped students to integrate the problems they identified in person with scientific knowledge gained in the classroom to design a practically applicable science project. The students also applied scientific methods to solve problems in new situations. They were able to make use of their knowledge and skills to design and undertake a practical science project that relates to the farming problems in their local area. The field trip to a coffee plantation in Cibulao, Bogor, Indonesia has driven students to identify problems, to design a problem-solving project, to conduct an experiment, and to communicate the results of their experiment on waste problem solving in the coffee plantation.

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