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Crab Peeling Waste in Rembang and Its Potential for Science Learning

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Abstract

The context Socio Scientific Issue (SSI) for learning is not o nly a global issue. Local environmental problems have a higher relevance to students' knowledge in learning. This study aims to analyze the potential and impact of crab peelings household industry waste in Rembang Regency and its potential as a SSI context in science learning. Data were collected through interviews, observation, and literature study using a descriptive qualitative method. The results showed that crab peeling waste could be utilized for making *petis*, natural food flavors, calcium and phosphorus sources, organic fertilizers, corrosion bio-inhibitors, fish and shrimp feed, metal absorbents, and food preservatives. Improperly managed crab waste harms the environment and public health, causing odor contamination, water contamination, and breeding grounds for flies and bacteria. The environmental problems caused by waste from the crab peeling household industry in Rembang Regency are controversial social issues with no immediate solution. Addressing these issues requires consideration of various factors, such as moral, ethical, cultural, traditional, economic, political, and environmental aspects, along with scientific understanding and community agreement for resolution. Therefore, the study of this matter has the potential to be raised as a SSI context in science learning.

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INTRODUCTION

There is a growing concern in education to address sustainability issues in school teaching and learning, leading to the notion of the importance of Education for Sustainable Development (ESD) (UNESCO, 2019). Learning that emphasizes the relationship between improving science literacy and addressing community engagement, both individually and collectively, is strongly recommended to achieve ESD (Schulz, 2009). Relevant learning is needed to prepare students for the changing times. Relevant science learning is defined as science learning that can provide students with a better understanding of themselves and their lives, a better understanding of the phenomena that occur in the environment around them, and ideas for solving emerging problems. In addition, science learning enables students to seize future opportunities through science learning. Undoubtedly, all these things are viewed from the perspective of science (Stuckey et al., 2013)

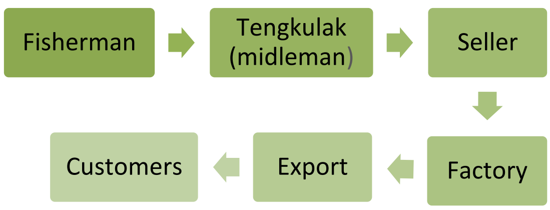
According to previous research, selecting learning models and approaches should prioritize relevance in science education. The Socio-Scientific Issue (SSI) learning strategy enhances relevance in science education. SSI teaches material about social attitudes, care, participation, and social issues in the environment and communication (Zeidler & All, 2005). The SSI strategy aims to increase intellectual, moral, and ethical understanding and awareness of the relationship between science and social life (Schenk et al., 2021) The focus of SSI is a controversial social or environmental problem, with multiple solutions (Birmingham & Barton, 2014). By using SSI in science learning, it is expected that students can see problems as science phenomena that are related to or even complete the concept of the science material being studied. Thus, the use of SSI in science learning is expected to provide science learning that is relevant to students and show how science affects society.(Uysal & Çaycı, 2022). Various literature studies conducted SSI can have a positive impact on science learning by offering students experience in applying scientific and ethical concepts and reasoning to relevant topics, improving students' argumentation skills (Dawson, 2024; Williams, 2022; Dawson & Carson, 2020), communication skills (Chung et al., 2016; Susilawati et al., 2021), decision-making ability (Ozden, 2020; Yuniartika, 2022), informal reasoning (Aziz & Johari, 2023; Han-Tosunoglu & Ozer, 2022; Cebesoy, 2021;Ozden, 2020), critical thinking skills (Davut Gul & Akcay, 2020; Kuo et al., 2019; Lombard et al., 2020; Torres & Matarredona, 2016), science literacy (Ke et al., 2021; Uzpen et al., 2019).

SSI incorporates issues that are controversial (open-ended, complex, unstructured problems) and cannot be easily addressed through memorized content knowledge, or simple algorithms (Tsai et al., 2019). The context used in this study is a crab peelings household industry in Rembang Regency.

Rembang is a regency in Central Java that produces the second-highest export of crab meat after Demak, which is around 16 tons per month. Crab meat production from Rembang continues to increase from year to year. The sub-district in Rembang that contributes the largest production of crab meat is the Kaliori sub-district. Partly a coastal area, the majority of residents in Kaliori sub-district work as fishermen or work in the fisheries sector such as middlemen (collecting traders), Sellers, or seafood traders. With the increasing export of processed crab meat, there are also more crab-peeling household industries in Kaliori sub-district. Currently, four villages in Kaliori have crab peeling industry groups: Sukoharjo, Tambak Agung, Tasik Harjo, and Purworejo. Crab raw materials that are processed in Kaliori sub-district are obtained from local fishermen and supplies from Demak area (Sari et al., 2016). Based on research conducted by (Sari et al., 2016) on the distribution of crabs in Kaliori sub-district, the distribution of crabs in the area was described. After fishermen go to sea to conduct crab-catching operations, the catch is directly deposited and sold to middlemen. The task of the middlemen is to supply the crab from the fishermen and do the crab boiling process for the Sellers. Sellers usually have several middlemen as suppliers of boiled crab for peeling. Groups of crab peeling workers, who are usually family members or neighbors, take 30-50 kg of crab every day from the middlemen to be peeled for a wage of Rp.15,000/kg. The peeled crab meat is then deposited back into the basket. The collectors then deliver the clean crab meat to factories in the Rembang Regency area to be packaged and exported. The crab distribution flow can be described as follows:

Figure 1. Flow chart of crab distribution in Kaliori sub-district, Rembang district.

The increase in the value and volume of processed crab exports in Rembang is also



followed by an increase in the amount of waste generated. Based on the research results, the largest amount of crab shell waste in Indonesia is in Central Java at 11.15 tons/day. (Amalia et al., 2021). The amount of crab waste produced in the crab peel household industry in Kaliori sub-district, Rembang Regency has also increased yearly. The waste generated from the crab peel industry is in the form of solid waste, namely shells, claws, other body parts, and liquid waste derived from cooking water (Hastuti et al., 2012). The process of processing and taking crab meat produces waste of about 40-60% of the total weight of the crab(Azizi et al., 2020). The shells and skins of crabs are mostly discarded, sold directly without processing, or just processed and then sold to collectors. Disposing solid and liquid waste from crab meat production certainly has the potential to cause negative impacts on the environment. On the other hand, the content of crab waste has many substances that have the potential to be utilized.

Rajungan is a group of crabs from the family *Portunidae* which is part of the *crustacean class Malacostraca* and order *Decapoda*. *Decapoda* has been the object of much research because it has a very high economic value and has a large diversity of species (Ernawati et al., 2015). Waste from shells, skins, and other body parts of crabs have useful chemical content including; 30-40% protein; 30-50% minerals ($CaCO3$); and 20-30% chitin (Natalia et al., 2021). The liquid waste from crab boiling contains high levels of protein and dissolved substances. crab liquid waste contains 17 amino acids with glutamic acid levels reaching 0.04% (b/v) (Mumtazah et al., 2021). With such content, crab waste certainly has a variety of potentials that can be utilized. This study aims to analyze the potential and impact of crab peel household industry waste in Kaliori Subdistrict, Rembang Regency. The objectives of this research are: (1) To find out the potential utilization of crab peel household industry waste that has been done in Kaliori Subdistrict, Rembang Regency, (2) To find out the impact of crab peel household industry waste for the community and the environment in Kaliori Subdistrict, Rembang Regency, (3) To explore the potential of analyzing the crab peeling industry as a learning resource in science learning based on the Socio-Scientific Issue (SSI) approach.

METHOD

The research method used is descriptive qualitative. The data collection techniques used were interviews, literature studies, and direct observation. This primary data collection was carried out through observation and interviews with the aim of making direct observations of objects. The results of the observations were information on the process of crab peeling and the relationship between crab peeling waste and its impact, while in-depth interviews were conducted directly with employees of the crab peeling household industry and the community around the crab peeling household industry. Secondary data collection was carried out through a literature study to obtain a theoretical basis and supporting data related to the potential and impact of crab peeling waste. In this research, the researcher is the main instrument for collecting data based on as much public knowledge as possible, carrying out verification, reconstruction, formulation and conceptualization into scientific knowledge. After the primary and secondary data verification process is complete, the next step is to analyze the potential of crab peelings household industry waste in Rembang Regency as a SSI context in Science Learning. The location of the observed crab peel household industry is in four villages, namely Sukoharjo, Tambak Agung, Tasik Harjo, and Purworejo. The research was conducted in March-Mei 2024.

RESULT AND DISCUSSION

Potential waste from the crab peeling household industry in Kaliori Sub-district, Rembang Regency.

Following in this part will describe the waste potential of the crab peel industry, it is necessary to first review the process of processing crab into export-ready meat products and the waste generated from the process. Based on observations and deep interviews with middlemen and crab collectors, the crab processing process starts with fresh crab, which is washed clean and then boiled until it is cooked and changes color to reddish. From this boiling process, liquid waste is produced from the rest of the boiling process. The resulting liquid waste is directly disposed of on the ground or in the waterways around the house. The cooked crab is then peeled and the meat is taken. Solid waste in the form of shells of the crab is then dried and sold to *pengepul* or collectors for Rp. 1,200,-/Kg. While chopsticks and other body parts from the stripping process are usually disposed of in the environment around the production house.

The waste management process can be observed through the following *Figure 2*;

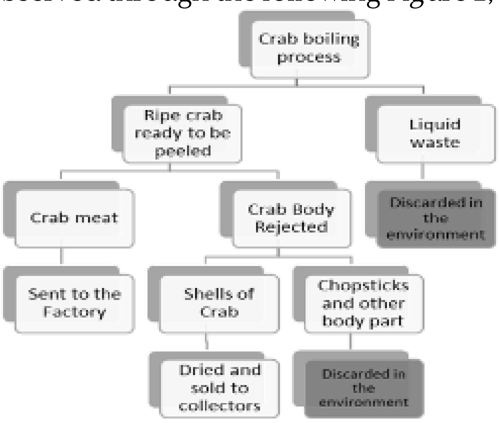


Figure 2. Crab peeling process and waste generated.

Based on interviews with crab middlemen in Kaliori sub-district, on average, one middleman gets 150-200 kg of boiled crab from middlemen every day. With a rough calculation, each basket can produce 75-100 kg of crab meat per day to be deposited to PT or factory. Assuming that the remaining peeled crab meat is waste, approximately 75-100 kg of crab solid waste is produced every day. The waste is in the form of skin, shells, and other body parts of the crab. Meanwhile, the liquid waste generated from the boiling process is approximately 20% of the weight of the crab. (Mumtazah et al., 2021) which is 30-40 liters every day.

Figure 3. Peeled crab meat production activities and the waste.

In Kaliori sub-district, Rembang district, 9 baskets house crab peeling household industries. If 1 basket can produce 75-100 kg of solid waste every day then the overall solid waste of crab peelings produced in the Kaliori sub-district of Rembang district is 675-900 kg every day. Meanwhile, the liquid waste produced ranges from 270-360 liters every day.

Figure 4. Crab shell waste is ready to be dried in the sun.

Based on interviews conducted with collectors and baskets in Kaliori sub-district, Rembang district, as well as observations at the production site, it was found that the liquid waste generated from the boiling process has so far only been disposed of in the surrounding environment either directly watered to the ground or through the waterways around the house. Meanwhile, the waste generated from peeling the crab in the form of shells is usually collected, dried in the sun, and will be bought by collectors at a very cheap price of around Rp.1,200,- / Kg. While other body parts waste, such as chopsticks and other crab body parts, are disposed of in the environment around the production site.

Figure 5. chopsticks and other body parts waste.

Based on the literature review, the remaining waste from the production of the crab peel industry, both solid and liquid waste, has great potential for further utilization. However, knowledge about the utilization of this potential is not widely known, especially to the residents of Kaliori Subdistrict, Rembang Regency. Based on interviews conducted with middlemen, baskets, and crab peeler workers, most of them do not know the potential of the crab waste. Middlemen said that so far no one has utilized the water used for crab stew. They also do not know the potential of crab liquid waste. The same information was also obtained from baskets and crab peeler workers. Based on literature studies, crab liquid waste can be utilized for various things, including:

Table 1. Potential Utilization of Crab Waste

Authors	Utilization of crab waste	Findings
(Mumtazah et al., 2021)	Raw material for making petis	Crab liquid waste can be utilized as a food flavoring ingredient such as *petis* because it contains 17 amino acids with glutamic acid levels reaching 0.04%. *Petis* produced according to this study has good quality that is not inferior to *petis* made from fish or shrimp waste.
(Adna Ridhani & Aini, 2021; Hastuti et al., 2012; Majid, 2019; P, 2014).	natural liquid food flavor raw material	Crab liquid waste can be utilized as a food flavoring ingredient such as petis because it contains 17 amino acids with glutamic acid levels reaching 0.04%. The potential of solid waste from the crab peel industry. The natural flavor produced from this research meets food quality standards and passes the organoleptic test with the average

Authors	Utilization of crab waste	Findings
		respondent liking the taste of natural flavor from crab shell waste.
(Adriyani et al., 2020; Al Faruqi, 2020; Mudaningrat & Ramdan, 2020; Rahma et al., 2019 Khasanah & Hartati, 2016;; Rochima, 2014; Yanuar et al., 2009)	A food additive source of calcium and phosphorus	Solid waste of crab shells and claws can be utilized as an additive that is a source of calcium and phosphorus. Research on the use of solid waste as a food additive has been conducted, including for the manufacture of crackers(Yanuar et al., 2009), making wet noodles (Khasanah & Hartati, 2016), Petis, broth, and crab crackers(Adriyani et al., 2020; Al Faruqi, 2020; Mudaningrat & Ramdan, 2020) beverages (Rochima, 2014) dried noodles(Rahma et al., 2019). Based on various research results above, the addition of powder from crab solid waste to food ingredients can add flavor and nutritional value, especially calcium and phosphorus.
(Abdul Kahar et al., 2022; Kurniawan et al., 2018; Gunawan R, Kusmiadi R, 2015;)	Materials for making organic fertilizer	Solid waste of crab shells and claws can be used for making organic fertilizer. Research on the manufacture of organic fertilizer from crab solid waste has been carried out by(Abdul Kahar et al., 2022; Gunawan R, Kusmiadi R, 2015; Kurniawan et al., 2018). Crab waste contains bound protein between 30%-40% of organic matter in the skin matrix. Protein is a source of limp substance (N) for plants because protein is composed of various types of amino acids. Crab also contains minerals such as Ca, which is the most important component, then Mg, and other minerals, namely K, Na, Fe, Cu, Zn, and P, in small amounts (Kahar et al., 2022) These elements are macro and micronutrients needed by plants.
(Awaliah et al., 2020; Titin Putri Awaliah, Dina Asnawati, 2020).	Bio corrosion inhibitor	Crab shell solid waste can be utilized as a bio-inhibitor to prevent corrosion of metals. Corrosion is the process of metal oxidation in the presence of oxygen which causes corrosion. The utilization of crab solid waste as a bioinhibitor has been carried out by (Awaliah et al., 2020; Titin Putri Awaliah, Dina Asnawati, 2020). Crab solid waste can be utilized as a bioinhibitor because it contains 20-30% chitin, which can be converted into chitosan to prevent corrosion. The study shows that the highest bioinhibitor efficiency occurred at a temperature of 303K with a concentration of 500 ppm.
(Kurnia et al., 2016; Umroh, 2016)	Fish and shrimp feed additives	Crab shell solid waste can be utilized as a raw material for making fish feed. Making fish feed from crab solid waste by first crushing the waste into

Authors	Utilization of crab waste	Findings
		powder, which is then used as raw material for making fish feed by adding several other ingredients. Research on making fish feed from crab solid waste has been carried out by (Kurnia et al., 2016; Umroh, 2016). Crab solid waste is used as raw material for fish feed because it contains a lot of protein which is beneficial for fish growth. Some types of fish used as research samples are tiger shrimp and catfish.
(Khoirul Muslih, 2011; Rahayu & Purnavita, 2017; Supriyantini et al., 2018)	Metal adsorbent	Crab solid waste can be utilized as a metal adsorbent. Several studies have proven that crab waste can be utilized as a metal adsorbent, including lead (Supriyantini et al., 2018) and mercury (Rahayu & Purnavita, 2017). Crab solid waste can be used as a metal adsorbent because it contains chitin which can be converted into chitosan. Chitosan can form complexes (chelates) with heavy metal ions and transition metal ions, especially Cu^{2+}, Ni^{2+}, and Hg^{2+}, but not with alkali and alkaline earth metal ions (Khoirul Muslih, 2011).
(Badarudin, 2018; Ridwanto et al., 2021)	Food preservative	Crab solid waste can be utilized as a food preservative. Several studies prove that crab solid waste can be utilized as a food preservative. Many research reported that crab skin solid waste is effectively used as a natural food preservative because it contains chitosan which is quite high. Some foods that have gone through research can be preserved with chitosan from crab solid waste including tofu (Badarudin, 2018) and fruits such as strawberries and *duku* (Ridwanto et al., 2021)
(Azizi et al., 2020; Djaenudin, 2019; Mahardika et al., 2020; Sartika, 2016; Tanasale et al., 2012; Martati, 2002)	Raw materials for chitosan production can be either solid or liquid.	The raw materials for making chitosan are both solid and liquid. Processing crab solid waste into chitosan, both powder and liquid, has also been widely done, considering that chitosan has many benefits in life. Various studies including those conducted to process solid waste into chitosan are carried out in various ways, both small-scale and large-scale industries, including those carried out by (Azizi et al., 2020; Djaenudin, 2019; Mahardika et al., 2020; Sartika, 2016; Tanasale et al., 2012; Martati, 2002)Based on these various studies, chitosan can be isolated from crab solid waste both at room temperature and at high temperatures.

Impact of crab peelings household industry waste in Kaliori Sub-district, Rembang Regency

In general, the community around the crab peel household industry has realized the negative impacts of solid and liquid crab peel waste on the environment and the community directly. Based on interviews with 5 (five) heads of households and 5 (five) crab peelers, the direct impact they feel is the appearance of unpleasant odors every day. This odor comes from the liquid waste left over from boiling and from the solid waste lying around the production site. There is no effort made by the collectors or workers to eliminate the odor because they consider that it is the risk of the crab peeling that they run. Residents in the vicinity of the production house also feel the same impact, namely the appearance of unpleasant odors throughout the day. However, they cannot do anything about it because their family members are also involved as crab peeling workers. Another impact is the large number of flies, both black flies and green flies, that swarm the crab waste. The flies are increasingly coming into people's homes during the fly season. This was felt to be very disturbing because even anti-fly drugs could not overcome the arrival of flies during the fly season.

Based on the literature study conducted, information was obtained regarding the impact of crab waste on the environment. Liquid waste from crab processing centers causes unpleasant odors due to the advanced decomposition of proteins rich in sulfuric amino acids (cysteine) producing sulfuric acid, thiol groups, and ammonia. The effluent also contains lipids (fats) which are a heterogeneous group of compounds related either actually or potentially to fatty acids. The nature of fat is generally insoluble in water, so waste containing fat has a considerable impact on disrupting aquatic ecosystems. This is also very likely to happen in the crab peel household industry in Kaliori Sub-district, Rembang Regency. Middlemen usually leave the liquid waste from boiling in the waterways just like that. Meanwhile, the estuary of the water channel is up to the river and finally to the sea. Crab liquid waste in the waterways causes the appearance of a layer of fat on the surface of the water. The fat layer on the surface of the water will block the entry of light in the water body so that the photosynthesis process is inhibited, thus oxygen levels will be low which will cause aerobic organisms to die (Oktavia et al., 2021).

Information obtained from residents and middlemen also often dispose of liquid waste directly to the ground during the dry season. Although the wastewater sinks quickly, it has the potential to pollute the soil. Enough wastewater can enter the soil to contaminate groundwater. If wastewater seeps into the ground near the well, the water quality of the well is no longer good, which can cause health problems such as itching, diarrhea, cholera, colitis, and others related to dirty water (Ken et al., 2019).

In addition to liquid waste, solid waste that is dumped in the area around the production house also has the potential to pollute the environment, including the swarming and nesting of flies. Crab solid waste becomes a fly nest because it has a distinctive aroma and contains a lot of protein and fat that is favored by flies. This fly can certainly have a serious impact on the health of the surrounding community. Flies are one of the vectors of disease transmission. Flies can spread disease-causing germs from waste to people through food. Flies can transmit about 100 types of pathogens that can cause disease in humans or animals. Among them are typhoid, cholera, dysentery, anthrax, and diarrhea. One of the causes of diarrhea is the contamination of food and drink by bacteria carried by flies. Flies are considered a nuisance because they prefer to settle in damp and dirty places, such as sewage. If the food inhabited by flies is polluted by microorganisms, either bacteria, protozoa, worm eggs/larvae, or even viruses carried and excreted from the mouth of flies, and when eaten by humans, it can cause diarrhea disease (Anwar & Sugiharto, 2018).

Crab solid waste is difficult to decompose because it contains high calcium (Zuchrillah et al., 2020). It is this calcium content that causes the waste to accumulate over time even though a hole has been made in the ground because it is difficult to decompose. Even so, other body parts such as gills and fatty tissue in the shell or skin of the crab are easily decomposed. This is what causes the unpleasant odor. The decomposition also gives rise to many bacteria that are lodged in the waste so it will be dangerous when carried by flies and infesting the food of the surrounding community (Widiyawati et al., 2022).

Based on the description above, the negative impacts caused by crab peelings need to be taken more seriously. Implementers of the crab peel industry should have a good waste treatment system that has been regulated by the Indonesian Minister of Environment Regulation so that when discharged into the environment (water, air, or soil) it does not cause pollution (according to environmental quality standards). However, for small-scale industries (households) this is still not well implemented because they do not have an adequate waste treatment system, and most waste from the household industry is directly discharged into the environment without going through the treatment process (Ken et al., 2019). Therefore, the local government through the environmental agency should pay attention to controlling the waste treatment of the crab peel industry which is quite a lot in Kaliori sub-district, Rembang district.

The potential of crab peelings home industry waste as a Socio-Scientific Issue (ISS) context in science learning.

"Context" is the circumstances that give meaning to words, phrases, and sentences. Contextualization provides "coherent structural meaning" for a new idea that can be put into a broader context(Sadler, 2011). Examples of this context should be considered significant to community life in today's society. When combined with environmental education and ESD, science learning that starts from context can become relevant education (Li & Eilks, 2024). SSI contexts include controversial social problems that are related to science, do not have immediate solutions, and require consideration of various factors, such as moral, ethical, cultural, traditional, economic, political, and environmental, and require scientific understanding and community consensus for resolution (Kumar, 2024). The UN has set 17 global goals, the SDGs, to address issues such as poverty, climate change, and justice. These goals aim to guide countries towards a sustainable future by 2030. With environmental literacy, SSI-based contexts can help create educational opportunities for the SDGs as half of the SSIs are environmental issues (Hernández-Ramos et al., 2021).

The alignment between SSI and the SDGs lies in the shared focus on interdisciplinary approaches to complex global issues. SSI and the SDGs emphasize informed decision-making, critical thinking, and responsible citizenship for the sustainability and betterment of society (Stouthart et al., 2023). Engagement in SSI facilitates the SDGs by fostering critical thinking and scientific literacy, while the SDGs provide a framework to address SSI in education and policy. Addressing environmental issues is central to the SDGs. Environment-based SSI contexts such as genetic engineering, renewable energy, and climate change encourage critical thinking, morals, and scientific literacy.(Ke, Zangori, et al., 2021; Sianes et al., 2022). However, using context in SSI is not only about global issues. Local environmental problems have a higher relevance to students' knowledge in learning (Zidny & Eilks, 2020).

The environmental problems caused by the crab peel household industry in Rembang Regency are local environmental problems that have occurred for a long time. Critical thinking about these environmental issues must be done to strengthen community involvement in overcoming environmental problems, including in education. The use of the problem of crab peelings waste in Rembang Regency as an SSI context in science learning can be assessed from various points, namely controversial social problems related to science, do not have direct solutions and require consideration of various factors, such as moral, and ethical, cultural, traditional, economic, political, and environmental, and require scientific understanding and community agreement for resolution (Kumar, 2024).

The environmental problems caused by the crab peel household industry in Rembang Regency are controversial social problems related to science. This problem is controversial because people's opinions are divided about it. Many people are disturbed by the impact of the waste, but many people do not mind the problem because they have been doing and experiencing it for a long time and even for generations. In science learning with SSI, students can see these problems from various perspectives. Thus, the crab peeling household industry in Rembang Regency fulfills the requirements as a controversial social problem related to science.

The environmental problems caused by the crab peel household industry in Rembang Regency are also not problems that can be solved with direct solutions. This is because the problem involves many parties and interests so a cross-factor assessment is needed to overcome the problem. Reviewing the environmental problems caused by the crab peeling household industry in Rembang Regency requires consideration of various factors, such as moral, ethical, cultural, traditional, economic, political, and environmental, and requires scientific understanding and community agreement for resolution. Catching and processing crabs is a local wisdom that has existed for generations in Rembang Regency. This is because, as a community living in a coastal environment, the profession of a fisherman and seafood processor has become their professional tradition. Various things related to community activities in processing marine resources certainly have both positive and negative impacts on the environment where they live. Because it has become a tradition, efforts to overcome environmental problems in their area certainly require cross-factor considerations such as morals, ethics, culture, political economy, and the environment. Providing scientific understanding and environmental ethics to the community certainly requires hard work and efforts from across sectors. However, this is precisely the opportunity to study environmental problems caused by the crab peel household industry in Rembang Regency as an SSI context in science learning.

CONCLUSION

Waste from the crab peel household industry in Rembang Regency has potential such as its use as raw material for making *petis,* raw material for natural liquid food flavors, additional sources of calcium and phosphorus in food, organic fertilizer-making materials, corrosion bio inhibitors, fish and shrimp feed additives, metal adsorbents, food preservatives, raw materials for making chitosan both solid and liquid. In addition, it also has negative environmental and social impacts, including pollution of soil and waters, disturbing aquatic ecosystems, and causing odors that disrupt the comfort of the community.

Environmental problems caused by the crab peeling household industry in Rembang Regency are controversial social problems, that do not have direct solutions and require consideration of various factors, such as moral, ethical, cultural, traditional, economic, political, and environmental, and require scientific understanding and community agreement for resolution. Therefore, it is an opportunity to examine environmental problems caused by the crab peeling household industry in Rembang Regency as an SSI context in science learning.

REFERENCES

Abdul Kahar, Busyairi, M., Siswoyo, E., Wijaya, A., & Nurcahya, D. (2022). Pemanfaatan Limbah Rajungan (Portunus Pelagicus) Untuk Memproduksi Pupuk Organik Cair Kitosan Sebagai Growth Promotor. *Jurnal Sains &Teknologi Lingkungan*, *14*(2), 122–135. https://doi.org/10.20885/jstl.vol14.iss2.art3

Adna Ridhani, M., & Aini, N. (2021). Potensi Penambahan Berbagai Jenis Gula Terhadap Sifat Sensori Dan Fisikokimia Roti Manis: Review. *Pasundan Food Technology Journal*, *8*(3),61–68. https://doi.org/10.23969/pftj.v8i3.4106

Adriyani, R., Erna, E., Siswanto, A., & Indrianto, R. (2020). Pendampingan Kelompok Usaha Kerupuk Rajungan Sebagai Upaya

Pemberdayaan Masyarakat Di Kawasan Pesisir Pantai Utara Cirebon. *Dimasejati: Jurnal Pengabdian Kepada Masyarakat*, *2*(1), 94. https://doi.org/10.24235/dimasejati.v2i1.6653

Al Faruqi, M. U. (2020). Pemanfaatan limbah cangkang rajungan (portunus pelagicus) sebagai produk pangan di Kabupaten Cirebon. *Jurnal Pusat Inovasi Masyarakat*, *2*(1), 12–17.

Amalia, K. P., Ekayani, M., & Nurjanah. (2021). Mapping and Alternative Utilization of Shell Crab Waste in Indonesia. *Jurnal Pengolahan Hasil Perikanan Indonesia*, *24*(3), 310–318. https://doi.org/10.17844/jphpi.v24i3.37436

Anwar, M., & Sugiharto. (2018). Higeia Journal of Public Health. *HIGEIA Journal of Public Health Research and Development*, *2*(3), 386–395.

Awaliah, T. P., Asnawati, D., & Hamdiani, S. (2020). Effectivity of Water-Soluble Chitosan from Rajungan Shell Waste as Corrosion Inhibitor on Iron in 1 M HCl. *Journal of Physics: Conference Series*, *1594*(1). https://doi.org/10.1088/1742-6596/1594/1/012004

Aziz, A. A., & Johari, M. (2023). The Effect of Argumentation about Socio-Scientific Issues on Secondary Students' Reasoning Pattern and Quality. *Research in Science Education*, *53*(4), 771–789. https://doi.org/10.1007/s11165-023-10099-5

Azizi, A., Fairus, S., & Jamilah Mihardja, E. (2020). Pemanfaatan Limbah Cangkang Rajungan Sebagai Bahan Kitin Dan Kitosan Di Purchasing Crap Unit Eretan "Atul Gemilang", Indramayu. *Jurnal SOLMA*, *9*(2), 411–419. https://doi.org/10.22236/solma.v9i2.4902

Badarudin, E. (2018). *Penggunaan Kitosan Dari Cangkang Rajungan Sebagai Pengawet Tahu. Pengantar, K. (2018). Disusun Oleh : PROGRAM STUDI TEKNIK KIMIA 2018.*

Birmingham, D., & Calabrese Barton, A. (2014). Putting on a green carnival: Youth taking educated action on socioscientific issues. *Journal of Research in Science Teaching*, *51*(3), 286–314. https://doi.org/10.1002/tea.21127

Cebesoy, U. B. (2021). Pre-service science teachers' informal reasoning patterns and risk perceptions in SSI: Case of gene therapy. *European Journal of Science and Mathematics Education*, *9*(4), 211–229. https://doi.org/10.30935/SCIMATH/11237

Chung, Y., Yoo, J., Kim, S. W., Lee, H., & Zeidler, D. L. (2016). Enhancing Students' Communication Skills in the Science Classroom Through Socioscientific Issues. *International Journal of Science and Mathematics Education*, *14*(1), 1–27. https://doi.org/10.1007/s10763-014-9557-6

Davut Gul, M., & Akcay, H. (2020). Structuring a new socioscientific issues (SSI) based instruction model: Impacts on pre-service science teachers' (PSTs) critical thinking skills and dispositions. *International Journal of Research in Education and Science*, *6*(1), 141–159. https://doi.org/10.46328/ijres.v6i1.785

Dawson, V. (2024). Teachers' support in developing year 7 students' argumentation skills about water-based socioscientific issues. *International Journal of Science Education*, *46*(3), 222–239. https://doi.org/10.1080/09500693.2023.2226334

Dawson, V., & Carson, K. (2020). Introducing Argumentation About Climate Change Socioscientific Issues in a Disadvantaged School. *Research in Science Education*, *50*(3), 863–883. https://doi.org/10.1007/s11165-018-9715-x

Djaenudin. (2019). Chitosan Extraction of Crab Shell on Different Time and Repetition Soaking. *Jurnal Teknologi Perikanan Dan Kelautan*, *10*(1), 49–59.

Ernawati, T., Boer, M., & Yonvitner, Y. (2015). Biologi Populasi Rajungan (*Portunus Pelagicus*) Di Perairansekitarwilayahpati, Jawatengah. *BAWAL Widya Riset Perikanan Tangkap*, *6*(1), 31. https://doi.org/10.15578/bawal.6.1.2014.31-40

Gunawan R, Kusmiadi R, dan P. E. (2015). Studi Pemanfaatan Smpah Organik Sayuran Sawi (Brassica juncea L.) dan Limbah

Rajungan (Portunus pelagicus) untuk pembuatan kompos Organik Cair. *Enviagro, Jurnal Pertanian Dan Lingkungan*, *8*(1), 37–47.

Han-Tosunoglu, C., & Ozer, F. (2022). Exploring Pre-service Biology Teachers' Informal Reasoning and Decision-Making About COVID-19. In *Science and Education* (Vol. 31, Issue 2). Springer Netherlands. https://doi.org/10.1007/s11191-021-00272-5

Hastuti, S., Arifin, S., & Hidayati, D. (2012). Pemanfaatan Limbah Cangkang Rajungan *(Portunus Pelagicus) Sebagai Perisa Makanan Alami*. 88–96.

Hernández-Ramos, J., Pernaa, J., Cáceres-Jensen, L., & Rodríguez-Becerra, J. (2021). The effects of using socio-scientific issues and technology in problem-based learning: A systematic review. *Education Sciences*, *11*(10). https://doi.org/10.3390/educsci11100640

Ibrahim, B., Trilaksani, W., & Riyanto, T. N. B. (2008). *[Recovery of Flavor Components from Blue Crab Processing Wastewater by Reverse Osmosis Technology] METODOLOGI Bahan penelitian*. *XIX*(1).

Ke, L., Sadler, T. D., Zangori, L., & Friedrichsen, P. J. (2021). Developing and Using Multiple Models to Promote Scientific Literacy in the Context of Socio-Scientific Issues. *Science and Education*, *30*(3), 589–607. https://doi.org/10.1007/s11191-021-00206-1

Ke, L., Zangori, L. A., Sadler, T. D., & Friedrichsen, P. J. (2021). *Integrating Scientific Modeling and Socio-Scientific Reasoning to Promote Scientific Literacy* (pp. 31–54). https://doi.org/10.4018/978-1-7998-4558-4.ch002

Ken, R., Jati, W. N., Yulanti, & Murwani, I. (2019). *Peranan Bakteri Indigenus dalam Degradasi Limbah Cair Pabrik Tahu The Role of Indigenous Bacteria in Degrading Liquid Waste of Tofu Production*. *4*(1), 8–15.

Khasanah, S., & Hartati, I. (2016). ANALISA PROKSIMAT MIE BASAH YANG DIFORTIFIKASI DENGAN TEPUNG CANGKANG RAJUNGAN(Portunus pelagicus). *Inovasi Teknik Kimia*, *1*(1), 39–44.

Khoirul Muslih, I. A. (2011). *PEMANFAATAN LIMBAH KULIT RAJUNGAN (Portunus pelagicus) SEBAGAI PENYERAP LOGAM BERAT (Pb, Zn, dan Cu) DI PERAIRAN KOLONG PASCA PENAMBANGAN TIMAH INKONVENSIONAL*. *5*, 5–8.

Kumar, V. (2024). Environmental socio-scientific issues as contexts in developing scientific literacy in science education: A systematic literature review. In *Social Sciences and Humanities Open* (Vol. 9). https://doi.org/10.1016/j.ssaho.2023.100765

Kuo, H. C., Tseng, Y. C., & Yang, Y. T. C. (2019). Promoting college student's learning motivation and creativity through a STEM interdisciplinary PBL human-computer interaction system design and development course. *Thinking Skills and Creativity*, *31*, 1–10. https://doi.org/10.1016/j.tsc.2018.09.001

Kurnia, A., Muskita, W. H., Astuti, O., Asnani, , & Harahap, W. (2016). Evaluasi penggunaan tepung cangkang rajungan sebagai bahan baku pakan juwana udang windu Penaeus monodon. *Jurnal Akuakultur Indonesia*, *15*(2), 117. https://doi.org/10.19027/jai.15.117-123

Kurniawan, K., Yunita, A., & Christianingrum, C. (2018). Peningkatan Produksi Pertanian Dengan Pemanfaatan Limbah Cangkang Rajungan Menjadi Pupuk Organik Di Pulau Seliu, Kabupaten Belitung. *Jurnal Pengabdian Kepada Masyarakat Universitas Bangka Belitung*, *4*(2), 54–61. https://doi.org/10.33019/jpu.v4i2.177

Li, B., & Eilks, I. (2024). Learning about Confucian ecological ethics to promote education for sustainable development in Chinese secondary chemistry education. *Chemistry Teacher International*, *6*(1), 35–47. https://doi.org/10.1515/cti-2023-0037

Lombard, F., Schneider, D. K., Merminod, M., & Weiss, L. (2020). Balancing Emotion and Reason to Develop Critical Thinking About Popularized Neurosciences. *Science and Education*, *29*(5), 1139–1176.

https://doi.org/10.1007/s11191-020-00154-2

Mahardika, R. G., Jumnahdi, M., & Widyaningrum, Y. (2020). Deasetilasi kitin cangkang rajungan (Poturnus pelagicus) menjadi kitosan menggunakan iradiasi microwave. *Al-Kimia*, *8*(2), 149–158. https://doi.org/10.24252/al-kimiav8i2.7999

Majid, S. N. (2019). Pemanfaatan Limbah Pengolahan Rajungan (*Portunus Pelagicus*) Sebagai Perisa Cair Dengan Penambahan Enzim Papain.

Martati, D. (2002). Isolasi Khitin Dari Cangkang Rajungan (*Portunus Pelagicus*). Kajian Suhu Dan Waktu Proses Deproteinasi. *Isolasi Khitin-Martati Dkk J. Tek. Pert*, *3*(2), 129–137.

Mudaningrat, A., & Ramdan, K. (2020). Kerupuk lemi Portunus pelagicus sebagai solusi pengelolaan limbah rajungan di wilayah Cirebon. *Prosiding Seminar Nasional V 2019*, 35–42. http://research-report.umm.ac.id/index.php/psnpb/article/view/3408%0Ahttp://research-report.umm.ac.id/index.php/psnpb/article/download/3408/3330

Mumtazah, S., Romadhon, R., & Suharto, S. (2021). Pengaruh Konsentrasi Dan Kombinasi Jenis Tepung Sebagai Bahan Pengisi Terhadap Mutu Petis Dari Air Rebusan Rajungan. *Jurnal Ilmu Dan Teknologi Perikanan*, *3*(2), 105–112. https://doi.org/10.14710/jitpi.2021.13147

Natalia, D. A., Dharmayanti, N., & Dewi, F. R. (2021). The Production of Chitosan from Crab Shell (Portunus sp.) at Room Temperature. *Jurnal Pengolahan Hasil Perikanan Indonesia*, *24*(3), 301–309. https://doi.org/10.17844/jphpi.v24i3.36635

Oktavia, D. A., Febrianti, D., & Yanuar, V. (2021). Pertumbuhan Bakteri pada Limbah Cair Perikanan Secara Spontan. *Prosiding Simposium Nasional VIII Kelautan Dan Perikanan*, 233–240.

Ozden, M. (2020). Elementary school students' informal reasoning and its' quality regarding socio-scientific issues. *Eurasian Journal of Educational Research*, *2020*(86), 61–84. https://doi.org/10.14689/ejer.2020.86.4

P, R. dwi. (2014). *pemanfaatan Portunus pelagicus sebagai flavour alami. lim*, 65–67.

Rahayu, L. H., & Purnavita, S. (2017). Optimasi Pembuatan Kitosan Dari Kitin Limbah Cangkang Rajungan (Portunus pelagicus) Untuk Adsorben Ion Logam Merkuri. *Reaktor*, *11*(1), 45. https://doi.org/10.14710/reaktor.11.1.45-49

Rahma, A., Abdillah, A. A., & Saputra, E. (2019). The Use of Rajungan (Portunus Pelagicus) Shells as Flour in Wet Noodles Ingredient. *IOP Conference Series: Earth and Environmental Science*, *236*(1). https://doi.org/10.1088/1755-1315/236/1/012124

Ridwanto, R., Indrayani, G., & ... (2021). Isolasi dan Penggunaan Kitosan Alami sebagai Pengawet Buah Strawberry. *Prosiding Seminar ...*, 494–503. https://www.e-prosiding.umnaw.ac.id/index.php/penelitian/article/view/795%0Ahttps://www.e-prosiding.umnaw.ac.id/index.php/penelitian/article/download/795/773

Rochima, E. (2014). Kajian Pemanfaatan Limbah Rajungan dan Aplikasinya untuk Bahan Minuman Kesehatan Berbasis Kitosan. *Jurnal Akuatika Indonesia*, *5*(1), 71–82.

Sari, M. P., Bambang, A. N., & Sardiyatmo. (2016). Analisis distribusi pemasaran rajungan (Portunus pelagicus) di Desa Sukoharjo, Kabupaten Rembang, Jawa Tengah. *Journal of Fisheries Resources Utilization Management and Technology*, *5*(1), 128–133.

Sartika, I. D. (2016). Isolasi dan Karakterisasi Kitosan dari Cangkang Rajungan (Portunus pelagicus). *Jurnal Biosains Pascasarjana*, *18*(2), 98. https://doi.org/10.20473/jbp.v18i2.2016.98-111

Schenk, L., Hamza, K., Arvanitis, L., Lundegård, I., Wojcik, A., & Haglund, K. (2021). Socioscientific Issues in Science Education: An opportunity to Incorporate Education about Risk and Risk Analysis? *Risk Analysis*, *41*(12), 2209–2219. https://doi.org/10.1111/risa.13737

Schulz, R. M. (2009). Reforming science education: Part I. The search for a philosophy of science education. *Science* *and Education*, *18*(3–4), 225–249. https://doi.org/10.1007/s11191-008-9167-1

Sianes, A., Vega-Muñoz, A., Tirado-Valencia, P., & Ariza-Montes, A. (2022). Impact of the Sustainable Development Goals on the academic research agenda. A scientometric analysis. *PLoS ONE*, *17*(3 March), 1–23. https://doi.org/10.1371/journal.pone.0265409

Stouthart, T., Bayram, D., & van der Veen, J. (2023). Capturing Pedagogical Design Capacity of STEM Teacher Candidates: Education for Sustainable Development through Socioscientific Issues. *Sustainability (Switzerland)*, *15*(14). https://doi.org/10.3390/su151411055

Stuckey, M., Hofstein, A., Mamlok-Naaman, R., & Eilks, I. (2013). The meaning of "relevance" in science education and its implications for the science curriculum. *Studies in Science Education*, *49*(1), 1–34. https://doi.org/10.1080/03057267.2013.802463

Supriyantini, E., Yulianto, B., Ridlo, A., Sedjati, S., & Nainggolan, A. C. (2018). Pemanfaatan Chitosan Dari Limbah Cangkang Rajungan (Portunus pelagicus) sebagai Adsorben Logam Timbal (Pb). *Jurnal Kelautan Tropis*, *21*(1), 23. https://doi.org/10.14710/jkt.v21i1.2399

Susilawati, Aznam, N., Paidi, & Irwanto, I. (2021). Socio-scientific issues as a vehicle to promote soft skills and environmental awareness. *European Journal of Educational Research*, *10*(1), 161–174. https://doi.org/10.12973/EU-JER.10.1.161

Tanasale, M. F. J. D. P., Killay, A., & Laratmase, M. S. (2012). Kitosan dari Limbah Kulit Kepiting Rajungan (Portunus sanginolentus L.) sebagai Adsorben Zat Warna Biru Metilena. *Jurnal Natur Indonesia*, *14*(1), 165. https://doi.org/10.31258/jnat.14.1.165-171

Titin Putri Awaliah, Dina Asnawati, S. H. (2020). Pengaruh Penambahan Inhibitor Kitosan Larut Air (*Water Soluble Chitosan*) Dari Cangkang Rajungan Terhadap Laju Korosi Pada Besi Dalam Larutan Hcl. *1*(x), 3–4.

Torres, N., & Solbes Matarredona, J. (2016). Contribuciones de una intervención didáctica usando cuestiones sociocientíficas para desarrollar el pensamiento crítico. *ENSEÑANZA DE LAS CIENCIAS Revista de Investigación y Experiencias Didácticas*, *34*(2), 43–65.

Tsai, J. C., Cheng, P. H., Liu, S. Y., & Chang, C. Y. (2019). Using board games to teach socioscientific issues on biological conservation and economic development in Taiwan. *Journal of Baltic Science Education*, *18*(4), 634–645. https://doi.org/10.33225/jbse/19.18.634

Umroh, S. dan. (2016). *Jurusan Manajemen Sumberdaya Perairan, Fakultas Pertanian Perikanan dan Biologi, Universitas Bangka Belitung*. 8–14.

Uysal, M. Z., & Çaycı, B. (2022). The effect of using web 2.0 tools in the primary school 4th-grade science course on various variables. *Participatory Educational Research*, *9*(1), 137–149. https://doi.org/10.17275/per.22.8.9.1

Uzpen, B., Houseal, A. K., Rusnayati, H., Herviana, G., & Sari, I. M. (2019). *Analysis of student ' s scientific literacy skills through socioscientific issue ' s test on biodiversity topics Analysis of student ' s scientific literacy skills through socio-scientific issue ' s test on biodiversity topics*.

Widiyawati, C., Hanifah, R. N., & P, D. Y. (2022). Kemampuan Koagulan Kitosan dalam Penurunan Konsentrasi TSS dan COD Pengolahan Limbah Cair (Review Jurnal) pertanian , aktivitas mineral , industri pengolahan , dan sistem pembuangan. *Tecnoscienza*, *6*(2).

Williams, J. M. (2022). *High School Students' Nature of Science Understandings and Scientific Argumentation Skills in the Context of Socioscientific Issues*. *May*.

Wu, Y. T. (2013). University Students' Knowledge Structures and Informal Reasoning on the Use of Genetically Modified Foods: Multidimensional Analyses. *Research in Science Education*, *43*(5), 1873–1890. https://doi.org/10.1007/s11165-012-9343-9

Yanuar, V., Santoso, J., Salamah, E., Yanuar, V., Santoso, J., Salamah, E., Teknologi, D., Perairan, H., & Perikanan, F. (2009). Utilization of crabs shell (portunus pelagicus) as sources of calcium and phosphorus in making of crackers product. *Jurnal PengolahanHasil Perikanan*, *12*(1), 59–72.

Yuniartika, M. D. (2022). Elementary School Students' Informal Reasoning and Its' Quality Regarding Socio-Scientific Issues. 2005–2003, *8.5.2017*, הארץ.

Zeidler, D. L., & All, E. (2005). Beyond STS: A research-based framework for socioscientific issues education. *Science Education*, *89*(3), 357–377. https://doi.org/10.1002/sce.20048

Zidny, R., & Eilks, I. (2020). Integrating perspectives from indigenous knowledge and Western science in secondary and higher chemistry learning to contribute to sustainability education. *Sustainable Chemistry and Pharmacy*, *16*(December 2019), 100229. https://doi.org/10.1016/j.scp.2020.100229

Zuchrillah, D. R., Pudjiastuti, L., Puspita, N. F., Hamzah, A., Karisma, A. D., Surono, A., Altway, S., Ardiani, L., Rohmah, N. A., & Ningrum, E. O. (2020). Karakteristik Biokomposit Edible Film dari Campuran Kitosan dan Pektin Limbah Kulit Pisang Kepok (Musa acuminata). *CHEESA: Chemical Engineering Research Articles*, *3*(1), 33. https://doi.org/10.25273/cheesa.v3i1.6659