

WASTE FINAL PROCESSING SITE BASED ON ENVIRONMENT AND EDUCATION IN BANYUMAS, CENTRAL JAVA, INDONESIA

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Abstract. One of the environmental problems found in developing countries, including Indonesia, is the waste problem. Waste management is the authority of the district or city government. Banyumas Regency is one of the areas that has experienced waste problems because the Final Processing Site (FPS) for its waste was closed and residents refused. In 2018, the Banyumas district received the title of waste emergency. At that time, in almost every corner of the city, there were piles of dirty and stinking garbage. Since the incident, it seems to be a whip for the local government to fix the waste problem. At present it can be said that they have been relatively successful in managing their waste, even to the point where the motto is that waste management is environmentally sound and educational. Based on that, it is interesting to study how the efforts were made and the criteria so that they dare to declare it as environmental and environmental-based waste management. The method used in this research is qualitative with interactive analysis. The results of the research show that waste management has been based on the environment with evidence in the form of; sorting waste from the source, processing which results in reducing the volume of waste at the sub-district and village level, product diversification from waste, processing into Refuse Derived Fuel (RDF) to achieve what is called zero waste. It has educational value because in the process of changing waste management through public education widely, especially in urban areas and more specifically to workers who are involved in various waste processing sites. In addition, the success of Banyumas Regency in managing waste is often used as a comparative study destination or a vehicle for education from various other local governments.

Keywords: Waste, environment, education, zero, Banyumas.

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1. Introduction

Waste problems still occur in many areas in the country, even in various countries [1,2,3] Likewise what was stated by [4] that cities around the world are expanding rapidly, taking up vast amounts of resources (e.g. construction materials, food, clean water, gas, oil, electricity) that feed their expanding economies. With cities being thermodynamic systems, an inevitable consequence of the continuous consumption of resources is waste materials, wastewater, and polluted air.

The waste problem is a problem that must be faced by the community, and becomes a local, regional, national, and even international issue, in line with the increasing population, technological advances, and lifestyles, so that it has an impact on increasing the number and types of waste generation which are increasingly diverse in each region. Garbage is a form of environmental pollution where waste can have an impact on public health, such as; odors, floods, aesthetic damage, fires, greenhouse effect, and so on. Until now there is no proper way to solve the waste problem, so it needs to be carried out in a comprehensive and integrated way from upstream to downstream so that it can provide benefits to the government and society in general, both in terms of economic, social, cultural and the resulting product is technology. environmentally friendly [5].

Banyumas Regency as one of the large areas also has the potential to have problems with waste. This area has a population of 1,776,918 people, spread over an area of 132,759 hectares. Administratively, the area is divided into 27 districts, 301 villages, and 30 sub-districts [6]. The relatively large population also produces quite a lot of waste every day. The total amount of waste is 480 tons per day, which has the potential to become a source of environmental pollution if it is not managed properly. The potential generation of generated household waste can be calculated by multiplying the number of residents by the coefficient of waste generated per person per day. Based on SNI S-04-1993-03 of 0.3-0.5 kg/day/life. The unit of waste generated from housing or households for permanent homes is 0.35 – 0.40 kg/person/day [7].

Banyumas Regency is also an area that has experienced serious waste problems. The peak of the period of bad waste management in Banyumas Regency was in 2018, when the final waste processing site (FPS) located in Kendalsada/Kaliiori Banyumas District was closed due to rejection by the local community. As a consequence of the rejection by the residents around the FPS, there has been the accumulation of waste in various Temporary Waste Collection

Points (TWCP) in various corners of the city of Purwokerto. This condition led to the fact that Purwokerto as the capital city of Banyumas Regency was experiencing a waste emergency. Garbage is not disposed of in FPS, while TWCP is not processed in any way, causing environmental pollution.

Since the emergency incident, the garbage seems to have become a kind of slap in the face for the local government. Then the Banyumas Regency government made serious efforts to manage its waste. Various waste management efforts have been carried out which are directly coordinated by the Regent of Banyumas. At present, there has been a very significant change in waste management, with the motto being environmentally sound and educating the community. The current waste management can be used as a model for waste management which is perhaps ideal for implementation in other regions.

Data on daily waste generation in Banyumas Regency as a whole is 608,214 m³/day, specifically in the Purwokerto Urban area, 106,845 m³ per day [8].

Table 1. Composition of garbage in Banyumas Regency per day

No	Composition of garbage	Percent (%)
1	Organic	52,88
2	Plastic	26,08
3	Paper	11,24
4	Glass	3,86
5	Metal	2,66
6	Cloth	0,76
7	Rubber/skin	0,66
8	Wood	0,63
9	Others	1,23
	Number	100

Source: Environmental Services Office. Banyumas (2020).

The proportion of organic waste (52.88 percent) that can be recycled is still the majority. However, the proportion of plastic waste that cannot be recycled is quite large (26.08%).

Community-based waste management is waste management that involves all layers (active participatory) of society with the aim that people realize that waste problems are the responsibility of all levels of society [9]. In this context, education and public awareness must be carried out. Because without the active participation of the community, good waste management will not be achieved. It is on the basis of this phenomenon that this paper is structured to describe the relatively successful waste management in Banyumas Regency.

2. Method

This study was designed as an analytic descriptive study. Descriptive is intended as a description that describes according to what is in the field. Analytics is defined as a review or analysis of existing data using certain analytical tools. Although this research is qualitative research, it is not classified as grounded research, which purely departs from the field empty-handed and then constructs a theory from the findings in the field.

Data collection is done by:

- 1) Interviews were conducted with waste managers and the community involved and those who contributed to waste in Banyumas Regency, which consisted of:
 - a. The manager of the Final Processing Site Base on Environment and Education (FPS-BEE)
 - b. The manager of Temporary Waste Collection Point (TWCP)
 - c. The manager of the community self-help group
 - d. Environmental service officials
 - e. Head of Neighborhood Association (RT)
 - f. Head of Citizens Association (RW)
 - g. The community generates waste.
- 2) Observation of the conditions and processes of waste processing at each waste processing site.
- 3) Documentation, searching data in the form of secondary data, and documenting important objects in the field.

The analysis in this study uses interactive analysis methods. The process used in this interactive research basically consists of 4 stages that move from data collection, data reduction, data presentation, and drawing conclusions [10]. The collection of data obtained from the results of interviews, observations, and documentation related to research. Data reduction is a form of analysis that confirms, sharpens, directs, removes unnecessary, focuses, and organizes data. Presentation of data in the form of narration, tables, and pictures. Drawing conclusions is manifested in the form of abstractions from various empirical realities found.

3. Result and Discussion

Environmental management must be carried out with the following principles: 1. The principle of State Responsibility "The state guarantees that the use of natural resources provides maximum benefit for the welfare and quality of life of the people, both the present and future generations", the state guarantees the rights of citizens to a good and healthy living environment, and: the state prevents activities of exploiting natural resources which cause environmental pollution and/or damage". 2. The Principle of Sustainability "that everyone bears obligations and responsibilities towards future generations and towards each other in one generation by making efforts to preserve the carrying capacity of the ecosystem and improve the quality of the environment. 3. Principle of Benefit This principle aims to realize equitable social welfare based on the principles of togetherness and balance to prevent economic disparities, social and cultural conflicts [11].

Fulfilling the environmental management principle requires innovation or change for the better. That's why there is an argument that says that change is something that is always there, even eternal in this world. According to [12, 13] that every social science theory, regardless of its conceptual starting point, will certainly focus on changes that describe social reality. This includes environmental management, especially waste management, which cannot be separated from changes. According to the [14] concerning waste management gives authority to district/city governments to organize their own waste management and the strategies they choose. Banyumas Regency 2014 which had closed the old FPS (Gunung Tugel) was moved to the TPA area in Kaliori in an effort to organize the waste management process. The Gunung Tugel landfill was closed because it was no longer suitable for the development of the population, which is increasingly living in the vicinity due to the expansion of the city.

3.1. Opening of BLE TPA

The new landfill in Kaliori village was opened by the Banyumas government in 2014 as a replacement for the old landfill which was managed by a landfill system, which was no longer conducive because it was pressured by the development of the city of Purwokerto. The FPS, which had been in operation for only 4 years, was finally closed in 2018. The closure was due to protests from residents because it polluted the residents' environment and the surrounding agricultural land. Figure 1 is a document of residents' rejection and their demands.



Fig. 1. Community's rejection of TPA, 2018

Demonstrations or residents' rejection of the landfill could not be extinguished, so it was finally closed. The process of demonstrating and closing the FPS resulted in the waste being accommodated in the TPS and residents piling up in various corners of the city. At that time, the condition of Banyumas looked very dirty because everywhere there were piles of garbage scattered around and even smelled bad. It was this condition that made Banyumas experience a waste emergency.

The waste emergency forces local governments to work hard to manage waste in their areas better. Since then, efforts to make various FPS IWPSs have been made. This effort has the support of the central government, especially the Ministry of Public Works and Public Housing (PWPH) through the Central Java Regional Settlement Infrastructure Center (RSIC). The support is in the form of the cost of constructing an Integrated Waste Processing Site (IWPS) in the Banyumas Regency. The IWPS is shaped like a *hanggar*, so it is often called a *hanggar*. The facilities for each hangar are in the form of office buildings, maggot rooms, maggot bio ponds, procurement of conveyor machines, organic waste counting machines, plastic pressing machines, waste sorting machines, 3-wheeled motorbikes, dump trucks, and waste processing facilities

In the early stages, 6 units of IWPS were built, which were built by the Ministry of Public Works and Public Housing in Banyumas Regency in different locations that were far apart. The six locations are; Cilongok District, Pekuncen District, Banyumas District, Rawalo District, Baturradan District, and Sokaraja District [15]. The description of the six IWPSs is as follows.

- 1) IWPS in Cilongok Village, Cilongok District with service coverage of 980 households, markets, and hospitals. This IWPS was built on village treasury land with an incoming waste processing capacity of 16 m³/day and 1.56

m³/day of residual waste. The processing of this IWPS produces output in the form of compost, inorganic waste ready for sale, maggot and maggot feed porridge.

- 2) IWPS in Karangklesem Village, Pekuncen District which is located in the Ajibarang Business area, Banyumas Regency. The IWPS was built on village treasury land with a waste capacity of 18.5 m³/day and residual waste of 1.79 m³/day to serve 1,500 families. IWPS management is carried out by the Karangklesem Village Community Self-Help Group (KSM) with a total of 25 workers with an estimated income of IDR 1,100,000/month.
- 3) IWPS in Kedunggede Village, Banyumas District with service coverage of 1,000 families. The capacity is 18 m³/day and the residual waste is 1.67 m³/day.
- 4) IWPS in Rawalo Village, RT 1 RW III, Rawalo District, with an incoming waste capacity of 22.8 m³/day and residual waste of 2.08 m³/day. This waste management system has helped absorb a workforce of 25 people and reduced waste from 1,000 beneficiaries (households) in Rawalo District, thus creating a clean environment, increasing the health value and comfort of local residents.
- 5) IWPS in Rempoah Village, located near the Baturaden tourist site managed by BUMDes. The IWPS was built with a capacity of 25.5 m³/day of incoming waste and 2.03 m³/day of residual waste with a service coverage of up to 3,210 households. In addition to producing compost and inorganic waste, the Rempoah IWPS management also produces maggot feed porridge so that it also helps maggot breeders who are around the IWPS.
- 6) IWPS in Sokaraja Kulon Village, Sokaraja District can reduce household waste consumption of 2,000 families. The IWPS was built at a cost of IDR 3.5 billion with a capacity of 17.3 m³/day and accommodated 1.63 m³/day of residual waste. Waste management at IWPS is almost the same as in other areas, namely developing a composting method. Organic waste that has been sorted and processed is processed into compost, while non-organic waste in the form of plastic bags is chopped and sold as raw material for products with economic value.

In addition to the construction of IWPS, the Government of Banyumas Regency also built an environment-based and educational final disposal site (FPS-BEE) located in Wlahar Wetan village, Kalibagor sub-district (Figure 2). This FPS landfill is equipped with a pyrolysis machine that can destroy waste by burning above 800 degrees Celsius. The FPS-BEE was built at a cost of IDR 49.7 billion with a budget composition from the APBN of IDR 41.9 billion (84.31%) and the APBD of IDR 7.8 billion (15.69%). This is a form of synergy for the development and management of FPS. Construction began in October 2020 and will be completed in December 2021.



Fig. 2. Final Processing Site - Based on Environment and Education (FPS-BEE)

FPS-BEE is able to accommodate 75 tonnes of waste/day with the concept of processing residual waste originating from TWC 3R, IWPS or PDU in Banyumas. The waste residue that enters directly is automatically chopped and sorted, then the sorted results are further processed to be utilized. Banyumas Regency Government is also working with PT Sarana Bangun Indonesia to deposit refuse derived-fuel (RDF) materials. Especially for FPS-BEE, it does not only focus on 3R (Reduce, Reuse, Recycle), but is also equipped with swimming pools, plastic factories, maggot cultivation sites, catfish farming, and other facilities.

3.2. Environmentally Friendly Waste Management

In environmental studies, we recognize the existence of the 2nd law of thermodynamics which states that not all of the available energy can be used to do work. In changing one form of energy into another energy always produces unused residue in the process. The remaining unused energy is called entropy. Entropy is what is called garbage. If waste is not managed properly, it will potentially become an environmental pollutant. Controlling any waste so that it does not become an environmental pollutant is necessary in order to lead to sustainable development [16,17].

According to Otto Soemarwoto, the law of thermodynamics means that, namely: First, pollution always occurs and cannot be avoided because there is always residue in energy use. Second, pollution can be minimized because the remaining energy or entropy is a source of energy for other energy uses. In other words, it can be concluded that the Law of Thermodynamics II is the foundation for waste management efforts. The waste or waste that we produce is a resource and energy for other energy uses, for example for compost, industrial raw materials and energy [18].

Law No. 32 of 2009 concerning the Protection and Management of the Environment defines that environmental pollution is the entry or inclusion of living things, substances, energy, and/or other components into the environment by human activities so that they exceed the established environmental quality standards [19]. Environmental quality standards are measurements of the limits or levels of living things, substances, energy, or components that exist or must exist and/or pollutant elements whose presence is tolerated in a particular resource as elements of the environment [19].

Pollution in the provisions of the law is entropy produced by human activities only, so if the entropy of other activities such as biotic components and natural disasters is not included in the category of pollution. Waste is entropy from human activities, so waste that is not managed properly has the potential to become a source of environmental pollution. Of course, with provisions whose existence exceeds the existing quality standards.

The community is a producer of waste, therefore it is appropriate to be responsible for and participate in waste management. This means that the community, the business world, and the City Government must jointly think of solutions so that the future of waste does not have a negative impact [20]. This is in line with the provisions of the Ministry of Environment and Forestry which considers that waste problems absolutely must be handled jointly by involving all stakeholders, namely the government, non-governmental organizations, universities, and the community itself. Therefore, awareness and joint commitment are needed to change attitudes, behaviors, and ethics that are cultured and environmentally friendly. In an effort to deal with waste problems to create a quality environment that is clean, green, and environmentally friendly, a paradigm shift in waste management must be carried out by reducing the volume of waste at the source by implementing waste reduction through the 3R movement (Reduce, Reuse and Recycle) with direct involvement by the community [21].

The very basic environmental principle in waste management is how waste can be managed and not become an environmental pollutant [22]. In this process, waste management in Banyumas has been made a proper effort, even though the local government is not fully responsible for it. Assistance from the central government, especially the Ministry of Public Works and Public Housing, really helped to realize the processing that is currently running. The ongoing process of waste management starts with sorting waste from the source, processing which results in reducing the volume of waste at the sub-district and village levels, product diversification from waste, processing into refuse-derived fuel (RDF) so as to achieve what is called zero waste.

About 50 tonnes of waste enter the FPS-BEE per day. As for the processing of incoming waste to those from various IWPSs, PDU, and hangars, it is processed through the following stages.

- 1) Garbage that has just entered is directly processed in the process through a BO machine. After going through the BO machine process, the output is in the form of waste pulp and plastic waste.
- 2) The waste slurry is processed through a drying process until the water content is less than 25 percent so that it is ready to become RDF (Rude Derived Fuel). In reality, the water content is only 17 percent.
- 3) Plastic waste is further processed through the Press-redder and Bypass processes, then to the Tromol Screen.
- 4) The output from the first Tromol screen is in the form of organic and heavy plastic, then through the Chopper and separator, the output is waste slurry plus RDF. The second Tromol Screen output enters the plastic sorter in the form of Gibrik and residue.
- 5) The Gibrik process produces waste and plastic pulp. The waste slurry is used for magot cultivation media, while the plastic factory in the BEE landfill also uses plastic factories for RDF and materials for making paving blocks and tiles.
- 6) Residues enter the pyrolysis process where the output is dust. The dust generated is only about 50 kg per day. The pyrolysis process according to [23] takes place without air in a closed system so no pollutants come out. At the beginning of pyrolysis, the unstable components and volatile compounds from the waste will break and evaporate. Converting plastic waste into fuel is one of the decisive solutions. The utilization of plastic waste as a source of liquid fuel is one method to reduce plastic waste accumulation.



Fig. 3. Waste processing in FPS-BEE

The residue that remains is in the form of dust which is not much in volume. The other residue is in the form of RDF which is then sold to the electric steam power plant (ESPP) in Cilacap as fuel in the power generation process. However, please note that RDF is sold at IDR 500,000 per tonne. This means that the price is not profitable if the distance

between the FPS and the ESPP or cement factory is far away. Banyumas and Cilacap districts are pretty close to ESPP or cement factories as the RDF market share so they support zero waste management.

3.3. Education-Based Waste Management

Much research on waste management has indeed been carried out, but the waste management that is currently running in Banyumas Regency is relatively new and different from the others. The abnormality of waste management in Banyumas is based on environmental insights and is meaningful as a vehicle for education for the community. One of the waste management that has been developed a lot is related to the economic value of waste which is developed in the form of waste banks [24,25]. Likewise, quite a lot of waste management based on sustainability principles has been studied by the following researchers [26,27,28].

The meaning of education in waste management, of course, is not included in the terminology of formal or non-formal education. A more appropriate education system is informal education. The definition of informal education is the path of education given in the family or neighborhood or community. Meanwhile, formal and non-formal education are educational paths that are tiered and structured [29].

Community-based education with a formal process is usually an education organized by a formal bureaucratic organization such as a school or university. Community-based education with non-formal processes can take the form of education outside the framework of a formal system that provides selected types of learning, such as in a library or museum. Meanwhile, community-based education with an informal process is education that is obtained by individuals through interactions with other people at work, with family, or with friends [30].

Education-based waste management in the form of involving local communities who are involved as managers both at the workforce and managerial level. In Banyumas Regency, 42 self-help groups (KSM) have been formed to act as the spearhead of waste management. The number of workers involved in waste management self-help groups, whether in the form of TPS, PDU or Hangar or TPST, is 929 people. Involving so many workers requires new knowledge and skills that some may not have known before. Therefore, the education process needs to be carried out in the new waste management process.



Fig. 4. An example of one KSM or TPST

According to [31] explains that the strategy and implementation of household waste management in urban Purwokerto is carried out by various parties and in stages. The Regional Government of Banyumas Regency, in this matter the Regent through the Environmental Service gave orders to the institutions under his authority. In stages, the command is for sub-district heads, village heads, and non-governmental groups (NGG) who manage waste. NGG is located in every village. Then, each village coordinating with KSM provide socialization, knowledge sharing, and empowerment together with the heads of RW and RT to residents or residents. It is the community members who are upstream in the comprehensive household waste management process.

In a hierarchical manner, information and implementers of waste management in Banyumas Regency. It is known that those who carry out waste management in the Purwokerto urban area in stages starting from the Regional Government, in this case, the technical service, namely the Environmental Service, then KSM as operators of waste management in each region, and lastly are households which are producers or sources of household waste. Household has an obligation to carry out waste management from their source in accordance with applicable regulations as outlined in the Banyumas District regional strategic policy [32].

There are several principles or values instilled in the community, namely:

- 1) Strive for waste to be managed at its source. This principle teaches that the implementation of the 3R principles must start from the community.
- 2) The oath of bear (turning waste into money), as a motto that is always echoed so that people are willing to sort and turn waste into goods that still have economic value.
- 3) The household is the upstream or end of the waste management process which is quite long. therefore the responsibility and participation of the household is very important in determining the success of waste management as a whole.

Now, Banyumas Regency is a model for other regions in waste management. Various other local governments have visited the Banyumas FPS-BEE in the context of comparative studies, used as a vehicle for education for their regions. Many local governments have studied in Banyumas. According to [33] that the regional government that attended Banyumas was a total of 68 districts that had visited Banyumas to learn about waste management. So the success of Banyumas Regency in managing its waste has become an education center for other regions.

With the success of waste management in Banyumas, the meaning base of education has expanded in dimensions. The current condition, FPS-BEE is not only based on education but has developed into an educational vehicle. So FPS-BEE functions as a place of education for the wider community from all over Indonesia, even at the international level. Why is that, because every time there is a comparative study group to FPS-BEE Banyumas, the head of the TPA always gives an explanation like a lecture. Likewise, when regents go abroad they are asked to explain about waste management in their area which is considered successful.

The success of waste management in Banyumas is not only a regional example in the country but also at the world level. The United Nations Framework Climate Change Conference (UNFCCC) invited the District Head of Banyumas to the 27th International Climate Conference or Conference of Parties (COP) in Sharm El Sheikh in Egypt which took place on 14 November 2022. For the Regent of Banyumas regency, being invited to the World Climate Conference is an honor. He explained how management in Banyumas from upstream to downstream. "Banyumas strives to handle waste from upstream to downstream. However, what is more, focused is handling it downstream. Not only to Egypt, the Regent of Banyumas was also invited by the United Nations Capital Development Fund (UNCDF) to attend Bangkok on December 5, 2022. "The agenda is to present the program proposals implemented by Banyumas. Because Banyumas will be the ASEAN Smart Green City pilot project," [34].

4. Conclusion

Since 2018, Banyumas Regency has been trying to manage its waste so that there is no need for a final waste disposal site (FPS). This goal will only be achieved in 2022 because the waste is managed on an environmental and educational basis. Environmentally based by sorting waste from the source, processing which reduces the volume of waste at the sub-district and village level, product diversification from waste, and processing into refuse-derived fuel (RDF) so as to achieve what is called zero waste. The success of managing waste to the zero waste level is not necessarily the result of Banyumas district's independent efforts, but also the existence of assistance from the central government in procuring the facilities. In addition, the luck factor is because it is close to the cement factory and electric steam power plant (ESPP) as a party that is willing to accept buying waste residue in the form of RDF.

The educational meaning of waste management is due to the change in waste management from the old pattern which was only a landfill pattern to this new pattern through a process of education and community empowerment. This education is not only for the workers involved in waste processing but also for the community in general. Because everyone is a waste contributor who needs to know, be aware of, and be responsible for the waste they produce. Socialization of new laws and policies that will be realized in waste management is always being educated to the community in stages until all households know about it. Households, which are upstream of a long waste management process, become partly responsible for the waste they produce. In addition, Banyumas Regency's success in managing waste has been used as a pilot project and education centre for other regency governments. By often being used as a place for comparative studies from other regions, education for the delegates is mostly from the environmental service and non-governmental groups (waste management) in their area.

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