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SCHOLARENA

Journal of Industrial Pollution Effects and Control

RESEARCH ARTICLE

Evaluation of Environmental and Social Impacts of Flour Factory: A Case of Kedija Flour Factory, Werabe, Ethiopia

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Citation: Fikadu Mamuye Bayu (2018) Evaluation of Environmental and Social Impacts of Flour Factory: A Case of Kedija Flour Factory, Werabe, Ethiopia. J Ind Pollut Eff Control 1: 101

Abstract

Assessing projects multi-dimensional impact plays a great role for sustainable development. The aim of this study was to determine and evaluate the potential environmental and social impact of Kedija Flour Factory found in werabe town, Ethiopia. At first, detail information about the industry's impact was identified by field survey. Then the identified impacts were evaluated according to EPA's standard and police, Proclamations and Regulations of the federal Democratic Republic of Ethiopia. The result of the study showed that, Kedija Flour Factory is operating, with production capacity of 18600 tons (t) of flour, which generates 1943.6 t of solid wastes annually. Of the total volume, 963 t and 980.6 t of solid wastes were generated in the elevator and in the milling sections of the factory respectively. From the total solid wastes, 61.7% was deposited in an open waste disposal site annually, and waste dumping in open area is causing serious negative environmental consequences. Similarly, waste water was discharged to the environment without any treatment; consequently, it affects the nearby households' health and the environment. The factory is also one source of air pollution by emitting 1.544 t of CO_2e yr^{-1}. In addition to this, the factory is causing 81 decibel (db) and 55 db noise pollution at its source and at the nearest settlement area respectively. Overall, the study concluded that, flour processing industry has potential environment and social impacts. However, if the recommended mitigation measures' are appropriately implemented the industry will contribute economic development of the country.

Keywords: Environmental Impact; Flour Production; Mitigation Measure

Introduction

Industries have an important role in the development of regions and countries. As industries grow and concentrate in industrial regions, the increase in waste production, degrading soils, polluting water, altering landscapes and threatening biodiversity on one side and the lack of necessary regulations for the management of these issues on the other side has made many regions in the world face serious challenges and has led to many environmental threats [1,2]. Regardless of the executive management of industrial waste, which has not been done well, in most circumstances the disposal of these waste is associated with a lot of trouble that leads to environmental pollution and encounters the natural ecosystems and human health with many hazards [3,4].

In turn, environmental impacts can impose significant economic and social costs on society, especially with regard to human health [5]. In response to the pollution and the unnecessary degradation of natural resources caused by rapid and unsustainable industrialization, agricultural development, and technological progress environmental impact assessment (EIA) was arisen as an assessment tool [6].

Since the 1960s, EIA has evolved as a comprehensive important management tool in giving decisions regarding ecological, social, economic and technical impacts of projects on the environments [7]. Health and sanitation are the important need and necessary of humankind as far as socio economic development directives are concerned [8]. For pollution prevention and environmental healthy, waste management activities should give attention by using appropriate science and technology.

In many regions, the industrial waste is burned unsanitary or enters soil and water and therefore, pollutes water and land [9,10]. One of the best, most economic and most environmental friendly industrial waste management activities is recycling [11,12]. In the past, the waste management mainly included collection, burning and disposal in land and there was no attention toward the recycling of industrial waste. As time passed with progress in science and technology, environmental knowledge increased and the relations between the environment and human health became more obvious [13,14]. On the other hand, the limitations of

material and water resources due to population increase and excessive uses became clearer and people realized that waste burning and dumping is associated with many problems and leaves serious negative environmental consequences [15]. Also, waste burning and dumping cannot solve the problem of increasing volumes of waste production [16,17]. Therefore, after a while recycling was described and it was clarified that we can use this method for managing industrial waste [18]. The production of material and energy, increase in the efficacy of industrial waste management, creating jobs, environmental sustainability and sustainable development are the aims of recycling [19,20].

Overall, for sustainable development project's environmental and social aspects need to be addressed properly [21,22]. Currently the constitution of Federal democratic republic of Ethiopia sets Policies proclamations and standards which need to be implemented for an economically viable socially acceptable and environmentally acceptable development [23].

Therefore the objective of this study is evaluating Kedija Flour Factory's physical, biological and socio-economic impacts and then recommending the possible mitigation measures to problems so as to make the project friendly to the environment and to the society.

Materials and Methods

Kedija Flour Factory is given an approval business certificate No. ስንዘ/13-01/01/30/04/03 on 14/12/2009 E.C. Kedija Flour Factory of worabe town silte zone, with 20,000 m^2 of land is located at the latitude and longitude of 6.9°N and 37.8°E of South nation and Nationality regional state of Ethiopia. The factory is installed 170 km away from the capital city Addis and it is surrounded by flour factories and very few residential settlements. Based on schedule of 300 production days per year, the plant produces 18600 tons of flour production.

Study material was selected in two steeps. Firstly, Werabe town was purposively selected because flour production is the main investment activity in the area. Secondly, since there is variation of practices in different industry, data collected from multi industries are highly aggregated, and generally give little information about individual processes. Therefore to avoid uncertainties arise due to aggregated information, assessment of the single industry is advisable [24,25]. Having this in mind, among nine (9) flour Factories found in Werabe town Kedija Flour Factory is randomly selected.

The research method was based on field studies and through questionnaires, local visits to Kedija Flour Factory. During site visit, checklists of processing operations; taking relevant measurements; were recorded. The aim of the questionnaire was to collect information about waste management and its steps including production, on site storage, collection, transfer, process, recycling and disposal.

Discussions were also held with residents, employee, officials and relevant professionals of the project in order to obtain information on the occurrence of unforeseen impacts, what mitigation and monitoring measures that have been implemented. In order to evaluate project's waste management activity, IPCC and EPA waste management standards were reviewed. Similarly the factory annual electricity consumption report was reviewed and then summed so as to calculate its total greenhouse gas emission. Finally, waste produced in different section of the industry was evaluated qualitatively and quantitatively.

Main technological processes in grain processing

In grain processing companies grains are stored and cleaned in an elevator department. Operation of elevator section equipment is based on the difference of grain and main features of impurities. This section consists of technological refinement devices: aspirators, separators, spiral settlers, machines for stone separation and magnetic apparatuses.

Cleaned grains are supplied to a grain processing department: Moisture is added by washing the grain to toughen the outside layer of bran so that it will come off in large flakes. Bran is undesirable in flour and is difficult to separate in the powdered state.

Grain is fed through a number of successively smoother rolls until it is reduced to its finished form. A screening operation between each set of rolls helps control particle size and separates out the bran. The bolters or sifters are also gradually reduced in effective mesh sizes down to a fine silk sieve. The finished product includes clear (rough) and pattern (fine) flour is produced in a milling department. The working principle of the milling equipment is based on pressing and shifting (rolls and millstones), striking (disk mills), striking and grinding (hammer mills) deformations. Rolls are used most frequently. Finally ready flour is packed and stored.

Results and Discussion

Impact Identification of Flour Factory

The most possible positive and negative impacts of the project were identified using survey checklist and data obtained from the respondents.

Positive Impacts

The project creates job opportunity for 44 people that enable them to generate income for their families. It also supplies 18600 tons

of quality flour /year to its customers. Similarly the project earns considerable profit to the proponent and also it increases revenue of the city administration through tax Table 1.

#	Impacts
1	Provision of 18600 tons of quality flour /year to its customers
2	Job creation for 44 people who were employed in different services of the factory
3	New opportunities for income generation for many individuals who has been supplied wheat to the grain mill
4	Increased economic activities directly or indirectly related to the project;
5	Possibility of savings for the local population and employee of the plant.
6	Payment of taxes to the local and central government
7	Create opportunity for the community to expose to modern gardening, recreation activities and agricultural development practices.
8	Enhances cultural transformation through which women of the area who are under cultural pressure can be benefited by encouraging them through employments opportunities.
9	Contributes to the realization of the development strategy particularly in the area of industry sector

Table 1: Positive Impacts of the project

Negative Impacts of Flour Factory

The respondents of flour processing industry have indicated that Solid waste, industrial waste water; Particulate Matter emission, greenhouse gas emission, Noise pollution and employee health problem are the most significant environmental and social impact of flour factory Table 2.

#	Impacts
1	Solid wastes
2	Wastewater
3	Particulate Matter emission
4	Greenhouse gases emission
5	Noise pollution
6	Impact of accidents

Table 2: Main environmental problems in grain processing companies (respondents'opinion)

Solid wastes

Annually the factory received 25479 t of grain for flour production. Grain was usually received in the uncleaned state and contains a variety of different types and sizes of foreign material including grain bran, chaff, rust, and weed seeds, various types of pollens, different mold spores, and pieces of grain, dirt, and insect parts.

Whenever grain is handled and strike against each other it tends to rub off small particles of chaff and to fragment some kernels. In this manner waste was continuously generated and the grain was never absolutely clean. Solid wastes were produced in to two main sections of flour processing departments. Initially, of the total amount of grain 25479 t reached in the Elevator or primary treatment section, 24516 t (96%) clean wheat and 963t (4%) solid wastes were produced.

The second sources of solid wastes was Milling section. Thus, at the milling department of the production section 18600 t (76%) of flour, 980.6 t (4%) solid waste and 4934.4 t (20%) of bran and other by products were generated. Annually 1943.6 t (8%) total solid wastes were produced from raw materials and manufactured products. If we consider 4934.4 t of Bran and Other by-products as solid waste, the amount of solid wastes increased to 6878 t /year Table 3.

Primary treatment section(grain separation from waste, grain shilling & primary processing)			**t/year**	**%**
	Total wheat received		25479	100
	Ready(Clean) wheat		24516	96
	Solid wastes		963	4
Milling section(flour processing)			**t/year**	**%**
	Ready (Cleaned) wheat		24516	100
	product	**Flour**	18600	76
		Solid wastes	980.6	4
		Bran and Other by-products	4934.4	20
Total solid wastes			1943.6	8

Sources: Data obtained from the industry

Table 3: Raw materials and Solid waste flows of flour processing Industry

Solid wastes from the grinding machines are mainly organic waste such as wheat residues from sieves i.e. impurities smaller or larger than wheat. Wastes from grain processing are considered to be nonhazardous wastes [26]. This category integrates waste from fruit, vegetables, cereals (grain), edible oils, cocoa, coffee, tea and tobacco preparation and processing; canned food production; yeast and yeast extract production, molasses production and fermentation [27]. However, some of these organic wastes may undergo decay and cause unpleasant smells, attract disease, causing vectors etc.

According to EPA waste management hierarchy option reduces, reuse and recycle are the prominent ways of waste managing method, lastly followed by waste disposal technique [28]. Data obtained from the project indicated that of 1943.6 t of solid waste generated annually 1200 t which means 61.7 % were deposited in an area protected for waste disposal site (Table 4). EPA set 50% maximum waste volume to be disposed by 2020 to reduce the overall environmental impact of solid waste. However, Kedija flour factory waste disposed volume 61.7% exceeds the '50 % EPA disposed waste volume.

Of the considerable EPA solid waste management options, the possibility of establishing recyclable/recoverable resources, like energy production are intended to be implemented [20-28]. Due to less technology option and lack of awareness, Kedija flour factory gives less attention to recycling waste management option.

Quantity of waste generated (t)	Maximum quantity waste allowed to be damped (t)	Waste Currently damped (t)	Waste urrently composed (t)
1943.6	971.3 (50%)	1200 (61.7%)	743.3 (38.3 %)

Source: Data obtained from the industry

Table 4: EPA obligations of solid waste recovery

Any Solid waste disposal site shouldn't be constructed within 40 meters distance from water bodies [28]. The EPA standard also states that wastes need to be disposed in well-constructed and closed dump. However, field observation of kedija flour factory indicated that, the project dispose wastes in an open dump disposal place nearly 37 m far from water body (Figure 1). Consequently, open dumps pollute surface and ground water, soil and the natural environment as a whole [28].

Figure 1: Solid waste disposal area

The hygiene and environmental sanitation regulation issued by Ethiopian proclamation number 1,1994 also prohibits people or projects from disposing waste along roads, avenues, rivers, ponds and other sites [8]. The finding of this study showed that, solid management trends of flour project have brought environmental and social effect.

Waste water

Water in flour production activity is used for watering (to reduce air emissions, to prevent fire), for wet shelling, for hot water and steam production. Kedija flour factory water waste hazards are minimal due to the fact that no chemical is used and that dry cleaning is usually employed. However, the projects waste water management activity is weak according to EPA waste management standard [28]. EPA indicated that projects can use a range of physical, chemical, and biological treatment technologies to manage waste water quality to acceptable levels. Then, the treated waste water is supplied to grow vegetables in the factory's compound. But sample project of this study discharge waste water to the environment without any treatment. Due to this wastewater of the grain milling factory can cause a number of impacts ranging from a loss of aesthetics up to affecting health of the nearby households [29].

Particulate Matter Emissions

Raw materials received in flour factory commonly contain much fine dust and long fiber shaped dust particles. Fine dust may include the actual soil in which the grain was grown, owing to wind or rain action in the field. Other fine particles may originate from weeds or insects or be produced from the grain itself by abrasion in handling and storing. In such way Particulate Matter (PM) gets in to the environment during all grain processing stages starting with grain entering the elevator to its milling processes. Besides, PM is emitted into the air during pouring and packing processes.

In Kedija Flour Factory, air emissions from the above organized sources (for example, air vents) are supplied to the solid parts treatment cyclones. In this factory, dust generated at the transfer points of the enclosed conveying equipment, carried through bucket elevators and emitted at the discharge of the conveyed materials. In addition, the cyclone dust separator is the main dust collecting device used for control of particulate air pollution. Similarly, inertial collectors of the factory remove grain dust particles and collects about 90% by weight of all types of dust emitted by grain operations [30]. Thus, in Kedija Flour Factory due to a wide range of dust control processes about 90-98% of emitted PM was controlled.

Therefore, PM Emissions in Kedija Flour Factory do not marginally increase because, all exhaust discharge points on the plant were fitted with buhler airjets filters which are capable of achieving an in stack particulate concentration. When Flour mill factory operates in accordance with manufacturer's instructions, PM emission causes less environmental impacts [31]. A study by Malcolm E. indicated that air contaminant problems encountered in milling are primarily dust emissions from the movement of raw grain. Emissions from the milling operation are well contained within the building by the use of a closed dust cleaning system. Fine particle size of the mill dust can be managed by the installation of air handling cloth type filters [32].

Even though, most of the PM emissions from the grain industry operations are controllable, remaining small dust settled on the floor and wall surfaces, or emitted to the environment through doors and windows has an effect on the environment and people's health. As a result, air pollutants in factory cause respiratory illness. Data obtained from the factory indicated that, two employees of the factory are affected with bronchial. A medical research by also shows individuals working in grain process factory faced effects of bronchial disturbances [31]. Therefore, we conclude that even though, PM emission is negligible due to appropriate operation; still it has a health impact to workers of the factory.

Total Greenhouse Gas Emissions

Over the past few years, a number of standards, tools, protocols and calculators have been developed to assist the industry in measuring levels of Greenhouse Gas (GHGs) emissions. These have been designed with a variety of end users in mind and utilize different methodologies for calculating and measuring GHGs emissions [33]. In order to calculate the CO2 e emissions to be attributed to electricity consumption, it is necessary to determine the emission factor. The general principle is that the national or a European emission factor was used. The greenhouse gas emissions calculation of this industry was based on the following assumptions [34].

The factory operates 24 hours per day, 365 days per year, except during maintenance and cleaning shut downs. Data of the project showed that the factory operates only 300 days per year. The project is closed on average for 65 days for Maintenance and power failure. The plant therefore operate for 7200 hours per year and its annual electricity consumption is 11, 7 MWh, (data obtained from the project). The total greenhouse gas emissions associated with the flour mill, the sum of the annual electricity consumption 11, 7 MWh was multiplied by the Ethiopian GHGs emission factor for electricity usage of 0.132 kg CO_2e/ KWh [35].

$$\text{Annual GHGs emission of the factory}(t) = \frac{\textit{Annual electricity consumption} \times \textit{Electricity Emission factor}}{KWh}$$

$$\text{GHG}(t) = \frac{11.7 MWh\ X\ 0.132 KWh \text{CO2e}}{1 Kwh}$$

$$= 1{,}544 \text{ t } CO_2e$$

So that the greenhouse gas emissions associated with the flour mill is 12,495 t CO_2e per year.

Impacts of Noise pollution

Noise pollution represents the exposure of people or animals to levels of sound that are annoying, stressful, or damaging to the ears. The maximum noise generated from kedija flour factory 81 db at its source and the minimum 55 db at the nearest settlement area (Table 5).

Category	Day time (07:00 – 23:00)	Night time (23:00 – 07:00)
Residential areas	55	45
Office buildings	60	50
Production facilities	81	71

Table 5: Summary of Noise level (db)

According to EPA noise limits, 55db at the nearest residences is in the range of acceptable the noise level. The permissible noise level to guarantee minimal comfort to humans is 65 – 80 db [28]. Since the industry is installed far from residential area noise problem is not an issue for the nearby residents. This has happened because the milling process takes place in an area only restricted for industrial zone. However, the noise level at production area is above the acceptable 80 db limit. Processing section, milling section and packaging section of the machines have singly and severally caused discomfort noise [36].

Environment pollution is unwanted product of different industrial activities that has exposed the environment to further danger [37]. Noise contamination is one of the extremely significant difficulties of the industries that influence the hearing procedure and other physiological factors of the human's body, as well as bodies in sound exposure situations [38]. High Noise level has resulted due to less management of rigid enclosure for rotary/vibratory screens and not appropriately covering bucket elevator transfer points with rigid enclosure. The study concludes that Kedija flour factory's noise level is disturbing the environment and people working in factory.

Impact of accidents

Ethiopian government Labor proclamation No. 377/2003 stated that employee should be protected in their working area. The proclamation also allows freedom of association and collective bargaining, equality of workers, waged and benefits and the like. It also states that an employer shall take the necessary measures to adequately safeguard the health and safety of the workers. Among safe working environment in the factories includes equipped employers with: high boots, protective uniform, dust masks, helmets and Eye goggles are the major one. Discussion with workers about safety and job security showed that, the project was given them the necessary equipment mentioned above. However, Most of them don't use safety equipments, felling discomfort. They also stated that the project do not force and aware them about the importance of safety equipments. This study examined that, though the factory provide safety equipments to employee, follow up their implementation is very less. In addition to this, important issues like insurance service in case of accident are not available. This study concludes, to avoid workers of safety equipments ignorance, it is advisable to provide regular follow up and training.

Conclusion and Recommendations

Conclusion

To minimize projects environmental and social impacts, it is necessary to identify the significant environmental aspects (results presented in Table 2).

In Kedija flour factory, 252479 t of wheat was processed with production capacity of 18600 tons t of flour, which generates 1943.6 t of solid wastes annually. Of the total volume, 963 t and 980.6 t of solid wastes were generated in the elevator section and in the milling section of the factory respectively. Malcolm E. showed that grain handling, cleaning, and storage are the main solid waste generating section in flour production industry [32]. From the total solid wastes, 61.7 % was deposited in an open waste disposal site annually, and waste dumping in open area is associated with many serious negative environmental consequences. The finding of Rojas-Valencia M, *et al.* also supports this result [15]. We concluded that, solid waste management trend of the flour project was causing environmental and social effect.

Similarly, waste water was discharged to the environment without any treatment, which affects health of the nearby households and the environment. EPA indicated that there is a direct relationship between waste water and increase of water borne diseases, which our research results supported [28]. From this it is possible to conclude that, Kedija flour factory water waste management system has negative impact on the environment and the people.

Kedija flour factory emitted 1,544 t CO_2e t CO_2e GHGs annually. Thus, total greenhouse gas emissions from all technological units are the other significant environmental and social aspect in flour processing industry. The finding by Petraškienė V, also shows, flour processing industry causes environmental and social problems [36].

In addition to this, the factory generates 81 db and 55 db noise level at its source and at the nearest settlement area respectively. Noise pollution was the other significant environmental and social issue in Kedija flour factory. A research of Mohammadizadeh M. indicated that, there is a meaningful relation between the occupational exposure to noise and the hearing loss [39]. The relation between the hearing reduction and work experience has been proven in a study done by Golmohammadi R [40].

Recommendations

It is recommended that Impacts of any development project depend on its activities, inputs, products and stresses of the development activity. In order to put into operation run the business and secure the sustainability of the project, the proponent and its technical personnel should work on cleaner production principles through the control of raw materials, control of processing, packaging, storage etc. based on the following mechanism.

Materials receiving

Proper planning and scheduling of the grain transporting vehicles must be carried out so as to minimize congestion and prevent

conflicts with local rush hours. Roads to have sufficient width to accommodate two- way traffic for the type of vehicles likely to be used for transport (farm trolleys, multiple axle trucks etc). Sufficient space needs to be allocated for the parking of the required vehicles inside the premises.

Wheat storage

A plan for preserving and maintaining the quality and contaminant, Free State of the grain in the storage area should be prepared and its implementation monitored. Only approved chemicals and processes should be employed for the preservation and fumigation of the stored grain. The chemicals should also be stored as per the manufacturer's instructions. All contaminated or moldy grain unfit for consumption should be disposed off in manner such that it would not be used for food.

Wheat milling (grinding)

Grinding machines that meet the criterion for noise levels in the workplace should be employed. Proper maintenance procedures must be enforced to ensure noise levels do not increase over time. Similarly the design of the conveying systems as well as the housekeeping procedures should ensure that leakage of dust is kept under control.

Packaging

Dust control is the major challenge in this area. Efforts to capture the dust at source will be most effective. Use of high efficiency filters is recommended.

Considering waste management recommendation in grain processing: either reusing solid waste for energy source which will enable the country to decrease the energy consumption from non- renewable energy sources or mixing Biodegradable waste with the other waste for production of high quality fertilizer.

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