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Research Article

The Effects of Cyanide Concentration on the Environment and the Consumption of Varieties of Cassava

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ABSTRACT

The environment is healthy when it has less and harmless pollution from any form of contamination. Cyanide is one of the contaminants that is responsible for degrading and changing the structural, biological, physical and chemical nature of the soil. Cassava (*Manihot esculenta*) is rated as one of the most popular crops in the world which can be consumed raw, cooked and also be processed into flakes (garri). Consequently, the cyanide concentration varies. The stages of processing cassava start from the peeling, washing, grating, dewatering and finally, frying. These processes are responsible for the deposition of cyanide into the environment. It is in view of these that this research was aimed at determining the best of the cassava variety to be consumed by determining the concentration of cyanide in the different varieties and the effects of cassava mill effluents to the environment in Nasarawa State, North-Central Nigeria. From findings, microbial and physicochemical analyses were conducted and it was discovered that TMS 98/0581 and Bernada which are among the improved varieties are the best to be consumed having a lower level of cyanide concentration of 4.8900 mg/kg and 5.1025 mg/kg respectively far below the acceptable limit of 10 mg/kg, after a standard cooking time of 35 minutes. When processed into flakes (garri), TMS 98/0581 and Bernada have the lowest concentrations of 0.2410 mg/kg and 0.4150 mg/kg respectively. Cyanide spillage affects both the biological and physicochemical structure of the soil by reducing the bacterial, fungal counts, the soil pH, BOD and COD respectively. The most dominant microorganisms present in the cyanide contaminated soil are acidophiles; which are *Campylobacter pylori (Helicobacter pylori), Aspergillus nigger, Lactobacillus planetarium and Klebsiella aerogenes*. They could be responsible for causing harmful bacterial diseases like peptic ulcer and pneumonia in both animals and humans. As we seek out solutions to these environmental effects, a process of creating a value chain was carefully studied and a recommended cassava layout was designed and was incorporated with a regurgitating machine to collect cassava mill effluents. The cassava peels could be grated, dewatered, dried and packaged as feeds for animals. Effluents could be channeled and stored where they can be converted to gas thereby connecting hoses and gas pipes to be used as a source of energy in processing cassava flakes (garri) in place of firewood or charcoal. The starch to be collected could be used in pharmaceutical, food and textile industries for drug formulations, food additives and cloth strengtheners respectively. These will result in saving our environment, mitigating diseases, creating job opportunities, improving the economy of the nation thereby adding to the value chain of cassava.

Keywords: Cassava varieties; Cyanide; Environmental effects; Microorganisms; Plant layout

INTRODUCTION

Cassava (*Manihot esculenta*) is considered as one of the major sources of carbohydrate in the world. According to rating, cassava is the third in the classes of carbohydrate after rice and maize. It serves as food in many communities in the developing countries [1]. Nigeria is rated as the highest, in the production of cassava in the world. In July 2018, it was reported that Nigeria produced about 53 million metric tons which is three times the production of Brazil and double the production of Indonesia and Thailand [2]. Other cassava producing countries in Africa are Democratic Republic of Congo, Ghana, Madagascar, Mozambique, Tanzania and Uganda

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which appears small in comparison to Nigeria's substantial output [2]. The North-Central zone produces the highest quantity of cassava with over 7 million tons a year followed by the South-South zone with over 6 million tons a year, South-West and South-East with less than 6 million tons a year. North-West and North-East are small by comparison at 2 and 0.14 million tons respectively [3]. In North-Central states, Nasarawa state is rated as the second highest after Benue state in the production of cassava [4]. Cassava is the most cultivated crop in Nasarawa state measured in metric tons per hectare (MT/Ha) at 19.6(MT/Ha) followed by sugarcane with 19.54 MT/Ha and yam at 19.43MT/Ha. Other crops are water melon (19.1MT/Ha), sweet potatoes (14.0MT/Ha), garden egg (11.40MT/Ha), pepper (5.02MT/Ha), maize and rice tallied at 2.36 MT/Ha, groundnut (1.60MT/Ha), sorghum (1.21MT/Ha) soybeans (1.19MT/Ha), millet (0.9MT/Ha) and beniseed (0.79MT/Ha) [5].

Almost all communities in Nigeria depend so much on cassava because of its wide usage when processed into garri, akpu, fufu, chips and starch. Before consumption, cassava usually undergoes processing as a means of detoxification, preservation and modification [6] due to the presence of cyanogenic glycoside in the unfermented leaves and roots [7]. The processing of cassava generates liquid and solid residues or wastes that are harmful to the environment [8]. Cassava peels and liquid effluent are the two wastes products that cause damage to humans, animals and environment which are derived during processing [9]. The peels and liquid are usually discharged on the land or into the water as waste resulting in environmental and health hazards [10]. Seepage and transient movement of water usually transport cyanide concentration to nearby water bodies or land within the region [11]. The Pollutant potential of the soil is always measured by the quantity of oxygen needed to oxidize the organic matter, the chemical oxygen Demand (COD) and the quantity of oxygen needed to stabilize the organic matter by the host microorganisms and enzymes and the biochemical Oxygen Demand (BOD) [7].

Cassava milling is one of the major activities of people in Nasarawa state as means of livelihood, therefore cyanic effluent is capable of contaminating or causing pollution to arable land and fresh water. It can also be inhaled by workers in or residing within the milling site where they can easily absorb the cyanide anion by mucus membrane of the respiratory tract or through the skin, especially the wet one and gastrointestinal tract [12]. Cyanide can also be consumed through processed cassava flakes (garri), cooked cassava and raw cassava and may have effects on consumers since varieties of cassava vary with cyanide concentration [13]. The consistent consumption of freshly processed cassava-based diet can reduce the growth of animals like goats, sheep, pigs, and African giant rats because of the cyanide concentration [14]. The continuous processing of cassava and also its demand and supply in Nasarawa state has accounted negatively on our environment, animals and humans and this informed the main objectives of this research as to determine the best of the cassava to be consumed by determining the concentration of cyanide in the different varieties, the effects of cassava mill effluents to the environment and to proffer solutions to mitigating these effects in Nasarawa State, North-Central Nigeria.

MATERIALS AND METHODS

Location

Nasarawa state is centrally located in the middle belt region of Nigeria as shown in Figure 1. The state lies between latitude 7o 45'

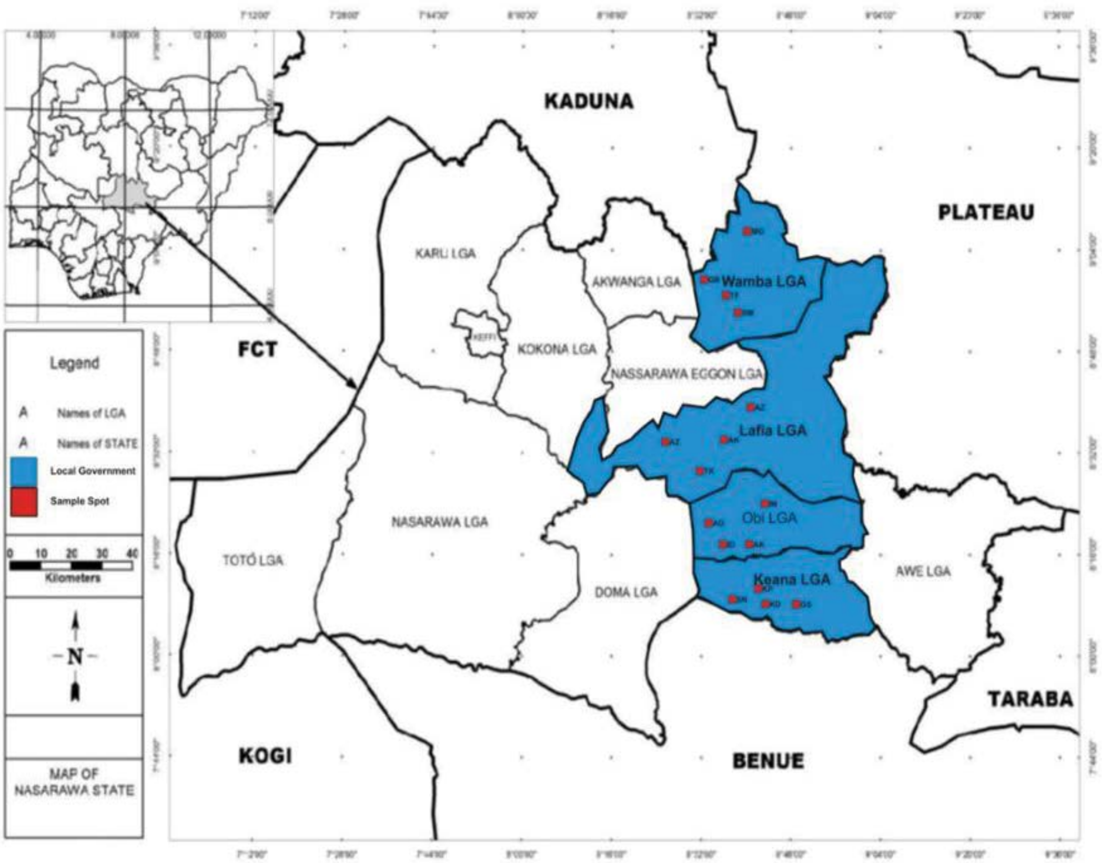

Figure 1: Map of Nasarawa State Showing the Location of the Study Area.

and 9o 25'N of the equator and between longitude 7o and 9o 37' E of the Greenwich meridian [15]. It shares boundary with Kaduna state in the North, Plateau state in the East, Taraba and Benue state in the south while Kogi and Federal Capital Territory flanks it in the West [14]. It has thirteen Local Government Areas namely Akwanga, Awe, Doma, Karu, Keana, Kokona, Lafia, Nasarawa, Nasarawa Eggon, Obi, Toto, Wamba and Keffi [15].

Samples Collection

Soil samples were collected from busy and popular milling sites of the state. Soil 1 and soil 2 were collected 20 meters apart. Controlled sample was collected 120 m from the milling sites at Lafia, Wamba, Obi and Keana Local government areas of Nasarawa state as illustrated in Figure 1. In Lafia Local government, samples were collected at Angwan Nungu(AN), Tudun Kauri (TK), Azuba Bashayi(AZ) and Akurba (AK) In Wamba Local government, samples were gotten from Gbata (GB), Maraban Gongon (MG), Traffic Junction (TF) and Small London(SL), In Obi Local Government, samples were collected at Agyaragu (AG), Akanga (AK), Imough (IM) and Idevi (ID), In Keana Local Government, samples were collected at Sarkin Noma (SN), Gidan Kpalev(GK), Gidan Sule(GS) and Kadarko (KD). A total of 3 samples of soil (Soil 1, soil 2 and control) were collected at each site totaling 48 and sealed using a nylon bag. 4 tubers of the most consumed cassava variety were collected at each site namely TMS 98/0581, Bernada, Chakachaka and Danwanga. Cassava flakes (garri) for each variety were collected at milling sites and were sealed.

Physicochemical Analyses

The analyses to determine the pH were measured using a digital HANA Combo pH meter. Stable readings were obtained by the introduction of the pH meter into the sample. The electrode was rinsed and sterilized after taking each measurement [16]. The cyanide concentration for cassava flakes (garri) and cooked cassava were determined using the Standard addition method [17].

Microbiological Analysis

The Pour plate technique was used to determine the bacterial and fungal counts of samples. 10g of soil 1, soil 2 and control soil were inoculated each into 90 ml of sterile water to give a 10-1 dilution [18]. Serial dilutions from the suspensions were prepared to a range of 10-5. 1 ml of 10-3 was aseptically plated out from these dilutions for total viable counts of bacteria on nutrient Agar and total fungal counts on potato Dextrose agar [19]. Colonies in each sample were observed and counted and were expressed as colony forming units (cfu/ml). Representatives of different purified colonies were subjected to various cultural, morphological and biochemical analyses [20]. Bergey's method of determinative bacteriology was used for the identification of bacterial isolate [21] and Wet Mount method of Yarrow for fungal isolates [22].

RESULTS AND DISCUSION

The pH of soil contaminated by cassava effluent is usually very acidic. This is due to the high cyanide concentration [23]. This spillage or effluents from cassava processing plants are harmful to the soil and the environment, therefore, they should not be allowed to spread over the soil due to infiltration or seepage [24] the availability of nutrients in the soil is determined by it pH [25]. Most plants grow in soil that is slightly acidic within the range of 6.2-6.8. When soil pH is outside these ranges, the nutrients are held up together though the optimal range for most plants is 5.5-7.0. Soil 1 and 2 are below these ranges; these shows that plants may find it difficult to grow around these milling sites, because of the consistent supply of cyanide to the soil around these areas [26]. Islamiyat et al. [27] reported that cassava peels contain a higher level of cyanogenic glycoside than the pulp, hence, the peels are typically lumped into the environment and allowed to decompose naturally. Soil 1 and 2 have the highest mean concentration of cyanide due to dumping of cassava peels and mills or effluents on the milling sites. Though from this research, the mean concentration of cyanide is lower than the detrimental value of 30 mgHCN/Kg [28]. The BOD and COD exceeds the detrimental value of 6 mg/l and 10 mg/l respectively. For drinking water <4 mg/l and <500 mg/l for effluent which are a threat to humans and animals' health [29]. High BOD is risky to fauna, flora and surface or underground water [30]. The presence of high BOD and COD might be as a result of the presence of high organic matter found in the soil. Hence, the organic matter required is broken down by bacteria thereby increasing the level of BOD and COD in the soil.

From Table 1 it indicates that TMS 98/0581 variety has the lesser concentration of cyanide when raw followed by Bernada. These two varieties are the improved varieties of cassava. Chakachaka and Danwanga are the local varieties mostly used in the state by farmers and have relatively high concentration of cyanide in that order. Abdulhamid et al. [31] reported that Nasarawa state is still left behind in the aspect of extension services in the adoption of new varieties of cassava for farming. Many farmers are not aware of the benefits of all the Tropical Manihot species (TMS) like the TMS 98/0505, TMS 98/0581, TMS 30572, NR 8082 and TME 419 which are rich in Vitamin A and have lesser cyanogenic concentration. This could reduce the level of peptic ulcer and eye defect by consumers of local cassava flakes (garri). Madugu and Umoh [14] reported that the ingestion of local fresh or processed cassava-based diet causes reduced growth in pigs, African giant rats, sheep and goats. According to [32] the recommended consumable level of cyanide concentration in cassava is 10 mg/kg (ppm) and the maximum time for cooking any variety of cassava is estimated to be 35 mins [33]. From Table 2 above, the improved varieties TMS98/0581 and Bernada after boiling for 15, 25 and 35 minutes at a boiling point of 100°C, it was discovered that TMS 98/0581 has the least concentration of cyanide at 4.8900 ppm followed

Table 1: The Mean Concentration of Cyanide and Some other Physiochemical Properties.

Parameter	Unit	Control	Soil 1	Soil 2
pH		6.70^{a}	3.14^{c}	4.40^{b}
Cyanide	mg/l	2.65^{b}	18.56^{a}	17.45^{ab}
BOD	mg/l	NA	7.34^{a}	6.67^{ab}
COD	mg/l	NA	1456.23^{b}	1678^{a}
Means bearing different superscript along the same row are Significant at 5% level of probability; BOD= Biochemical Oxygen Demand; COD=Chemical Oxygen Demand; NA=Not available Ppm=Part per million				

Table 2: Mean Values of Cyanide Contents in Ppm in Cassava Tuber /Process Samples.

Cassava Samples	T	B	C	D	M
Cyanide in raw cassava tubers	38.2500[c]	43.5251[b]	53.1875[ab]	60.9275[a]	
Cooked cassava 15 mins	14.3150[c]	21.6051[b]	23.3201[b]	27.3875[a]	
Cooked cassava 25 mins	8.7700[c]	12.1875[b]	13.8951[a]	15.8525[a]	
Cooked cassava 35mins	4.8900[b]	5.1025[b]	7.9625[a]	9.6025[a]	
Cyanide in garri	0.2410[d]	0.4150[c]	0.56725[b]	0.6367[ab]	0.7275[a]

Means bearing different superscript along the same row are Significant at 5% level of probability (Variety: T= TMS 98/0581, B=Bernada, C=Chakachaka. D=Danwanga M= Mixed varieties of garri and Ppm=Part per million

by Bernada with 5.1025 ppm both having the same superscript showing that the two products are safe to consume. The local products of Chakachaka and Danwanga with a concentration of 7.9625 ppm and 9.6025 ppm having same superscript respectively are close to the world Health recommended standard, this shows that consuming local cassava frequently will accumulate cyanide concentration which could be harmful to health for both animals and humans. In cassava flakes (garri), the cyanide concentration after processing is still very less in the improved varieties of TMS 98/0581 and Bernada, relatively acceptable concentration in varieties of Chakachaka and Danwanga. In mixing all these varieties together, it was discovered that the concentration of cyanide is 0.7275 ppm which is almost to the standard of WHO. This shows that mixing garri from different varieties could be harmful to health when frequently consuming.

Table 3 presented the microbial population in control sample, soil taken from spot 1 and 2 on the same milling sites. The bacterial and fungal counts were found to be highest in the control sample (0.005468 and 0.043246 cfu/ml) and lowest in Soil 1 (0.005032 and 0.002638cfu/ml) and followed by soil 2 (0.004746 and 0.002475 cfu/ml) respectively. The decrease in microorganisms is as a result of effluent disposal at the milling sites, where many organisms died due to cyanide concentration. Table 4 below shows the isolated microorganism which included *Staphylococcus aureus, Lactobacillus planetarium, Bacillus subtillis, Fusarium solani, Aspergillus nigger, Saccharomyces ceravisae, L.debruiki, Klebsiella aergenes* and *Campylobacter pylori*.

From Table 4 above, the microorganisms discovered from the field are *Campylobacter pylori* (*Helicobacter pylori*), *Aspergillum nigger, Klebsiella aerogenes* and *Lactobacillus planetarium* which have 18.644, 16.950, 13.560 and 13.560% respectively. *H. pylori* is a gram-negative bacterium that causes inflammation and infects the stomach and duodenum. *H. pylori* is a common cause of ulcer in human beings [29]. Victor et al. [34] reported that 56.3% of patients attending healthcare facilities in the state were diagnosed to be infected with ulcer. The above result conforms to the findings where 18.644% of the soil samples are of *Helicobacter pylori*. Inhabitants of the state suffer from peptic ulcer because this organism is an acidophil, and the cyanide environment is found to be the best host for this bacterium. From the sample site, there are greater chances of *H. pylori* to flow due to surface runoff or infiltration to nearby water bodies around the state and these waters is consumed without treatment. *Aspergillums nigger* has 16.950%. Massive inhalation of Aspergillus spores by a normal person can lead to an acute, diffuse self-limiting pneumonitis [35]. The primary hazard of this organism is that it can cause pneumonia to both humans and animals due to toxicity associated with the production of mycotoxin known as malformins. The ingestion of these organisms in feeds can cause death of animals when consumed with time [35]. A demographic survey by Child and Family Health carried out in Nasarawa State [36] reported that pneumonia caused 11% of infants' death. Similarly, Abu et al. [37] reported that 66% of animals died due to pneumonia. This research shows that Aspergillus nigger could be one of the bacteria that causes pneumonia in animals and in humans especially children in the state. Because many children take their bath in these streams and this same water has been in use for both humans and animals. Sheep and goat straying about these milling sites consume cassava peels which could be the host of *Aspergillus nigger* and drink these waters from the streams.

From this research, *Klebsiella aerogenes* rated as the third most discovered organisms with 13.560%. These organisms occur in the lungs where they cause destructive changes such as necrosis, inflammation and hemorrhage within lung tissue, sometimes producing thick and bloody mucus [38]. Some common diseases associated with Klebsiella include urinary tract infection, pneumonia, meningitis and lower respiratory tract infection [39]. According to the United State department of Health and Services [40], during the fermentation process in factories or industries, most workers carrying out harvesting, extraction and processing and people residing close to any fermented area can expose themselves to *Klebsiella aerogenes*. In Nasarawa State, a research was conducted by kolawole et al. [41] reported that 66.67% females and 33.33% males in the state were diagnosed to be positive of urinary tract infection disease. It was shown that Klebsiellia contributed the highest among other related organisms like the *E. coli*, Pseudomonas aeruginosa and Proteus mirabilis in causing urinary tract infections [41]. This shows that *Klebsiella aerogenes* and other related organisms still exist in our environment causing pneumonia and urinary tract infection.

Lactobacillus planetarium also rated as the third most discovered organism with 13.560%. This is commonly found in many fermented food products as well as anaerobic plant matter [42]. The existence of this organism in this research could be as a result of the fermented environment due to the spillage of cyanide.

CONCLUSION

From the research, modern facilities to control the spillage of cyanide into the environment have not been made available by any organization or agency. A careful study was conducted on the safe facilities to handle the spillage of cyanide, and to provide a convenient environment for garri (cassava flakes) processing workers in the state. To reduce the threat of cassava peels in the environment, cassava peels can be grated to reduce particle size, dewatering and drying to a moisture of 10-12% and further be used as animal feed thereby reducing the rate of diseases by humans, cattle, sheep and goats. The design in Figures 2 and 3

Table 3: Mean Microbial Population (cfu/ml) in Cassava processing Plant soil Samples.

Microbial Counts(cfu/ml)	C	S_1	S_2
bacterial count	0.043246[a]	0.005031[b]	0.004746[b]
fungal count	0.005469[a]	0.002638[b]	0.002475[b]
Means bearing different superscript along the same row are Significant at 5% level of Probability; C=Control. S1=Soil sample 1, S2=Soil sample 2.			

Table 4: Occurrence of Isolated Microorganism.

Isolated Microorganism	Number Positive Result Across Double Sample	Number Positive Result Across Single Sample	Total (Percent %)
Staphylococcus aureus	2	2	4 (6.779)
Lactobacillus planetarium	2	6	8 (13.560)
Bacillus subtillis	3	3	6 (10.170)
Fusarium solani	2	4	6 (10.170)
Aspergillus niger	4	6	10 (16.950)
Saccharomyces ceravisae	2	2	4 (6.780)
L. debruiki	2	0	2 (3.389)
Klebsiella aerogenes	6	2	8 (13.560)
Campylobacter pylori	5	6	11 (18.644)

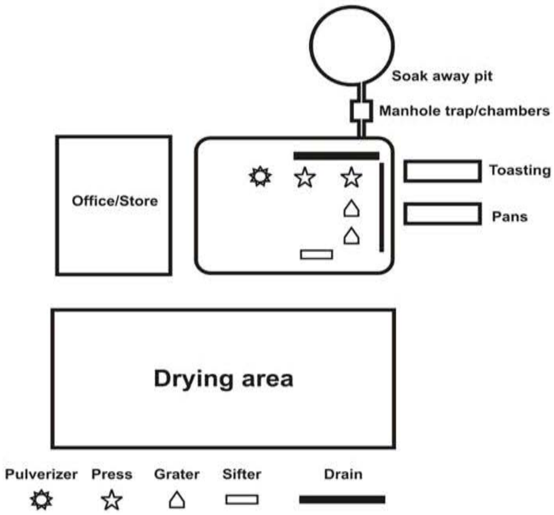

Figure 2: The plant layout.

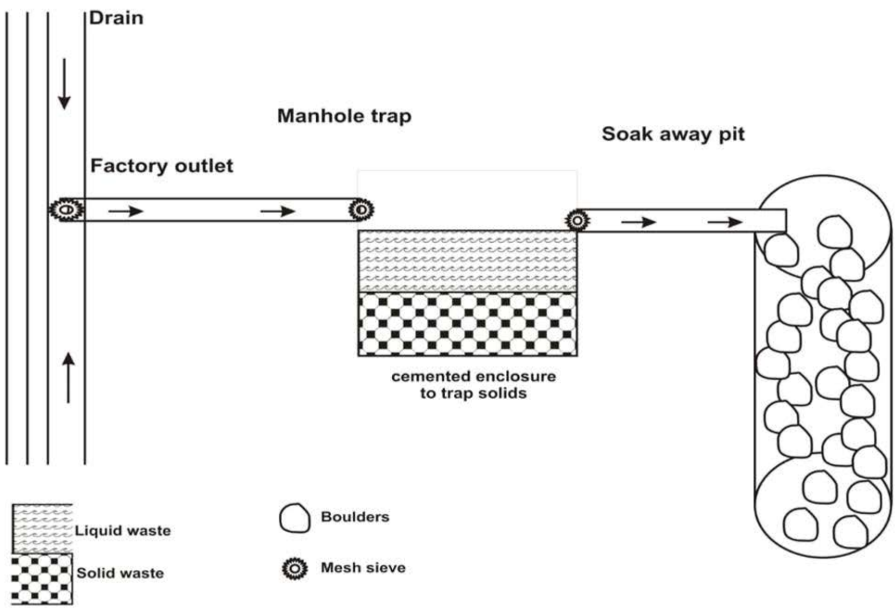

Figure 3: Components of the layout.

below indicates the plant layout and its components made up of boulders to sterilize the cyanide concentration thereby extracting the starch. Nigeria which is the biggest producer of cassava imports 95% of its industrial starch, a by-product of cassava. He further stated that Nigeria spends $580 million yearly in the importation of starch. If the government or concerned agencies will recommend this layout and its components, it will save the environment from pollution, reduce the high rate of diseases caused by these acidophil organisms from affecting humans and animals. Nigeria will supply its homemade starch to Pharmaceutical companies for drug formulations. Food and Textile industries will also benefit from the availability of starch in the country thereby creating a value chain from cassava. The effluents in the pits can be used as biodiesel by connecting hoses and burners channeling the gas to frying pans to serve as fuel in frying garri instead of using firewood. Economically, dried cyanide free cassava peels can be packaged and sold in healthy condition to feed animals at subsidized rates. Nigeria can equally also become a major supplier of cassava peel chips to other countries of interest thereby boosting our Gross Domestic Product (GDP).

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