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ASSESSMENT OF POLLUTION LOAD AND PREVENTIVE MEASURES FROM CASHEW NUT PROCESSING INDUSTRIES

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ABSTRACT

Cashew Nut Industries are mostly in small scale and cottage sector without any effective pollution abatement system. Though the pollution load from individual unit is relatively small but the magnitude of pollution problem from the cluster of units becomes very high. With this objective a study was taken up to assess the pollution problem from Cashew Seed Processing Industries. This paper deals with the assessment of Pollution load from the cashew nut processing and suggest techno-economically viable pollution control technologies, for gaseous emissions, wastewater discharge etc.

INTRODUCTION

India is the largest producer, processor and exporter of cashew in the world (The cashew Export Promotion Council of India) and accounts for over 66% of the world exports of cashew kernels. There are around 1500 cashew nut processing industries in India. The industry is categorized as small scale/ cottage units and there are about 300 units scattered in Nagercoil district, Tamilnadu, about 270 units in Kollam district, Kerala and about 130 units at Palasa-Kasibugga, Andhra Pradesh. There are also concentration of these industries in Cheerla-Andhra Pradesh, Mangalore–Karnataka, Maharashtra, Orissa and few units in Goa. The capital investment on the units is varying between 6.0 lakhs-15.0 lakhs. Even though there is cashew nut (seeds) cultivation in the country, most of the production demand is met by importing Cashew Nut from South Africa. Since these industries are small and cottage category units and no conventional and techno-economically cost effective pollution abatement systems are in operation elsewhere, a study was done for entire cashew nut processing industry sector in India to suggest techno-economically feasible environmental standards.

Process description and sources of environmental pollution

The main function of the cashew seed processing industry is the recovery of the kernel from raw nuts (T.V. Ramachandra, Energy Research Group, Centre for Ecological Sciences) . The cashew nut processing is highly labour intensive, (About Cashew: Directorate of Cashew Nut & Cocoa Development, Govt. of India, Ministry of Agriculture). There are two commonly followed methods of cashew nut processing, viz. Roasting process and Steam (roasting) Cooking process. The major steps in cashew nut processing (Fig. 1) are: (COINDS/75/2007).

Roasting Process
- Roasting
- Shelling
- Borma
- Peeling
- Grading & Packing

Cooking Process
* Cooking
* Cutting
* CNSL extraction
* Borma
* Peeling
* Grading & Packing

In cooking process vegetable oil is extracted from

the cashew shell of the seeds, which is called Cashew Shell Nut Liquid (CSNL) has valuable industrial uses as a raw material for the manufacture of resins, paints, dyes, insecticides, preservatives etc. (Russel, 1996). The manual traditional method of shelling cashew nuts using harmer is a labour-intensive and has some health implications due to the corrosive action of CSNL on human skin (Ojolo and Ogunsina). Due to lack of skilled man- power for cutting process of cooked nut, most of the industries are following roasting process.

In the cashew nut roasting process, thick black smoke is released from the rotating roasting drum through the stack. Air emissions in the form of thick black smoke are the major pollutants generated from the cashew nut units. The smoke, when it reaches the ground, has irritating odour and is public nuisance in the neighborhood. High concentration of Suspended Particulate matter (SPM), NO_x, CO, SOx and phenol compounds are the major pollutant constituent of smoke emissions.

The combustion of raw cashew nuts in the drum roaster, i.e. combustion of CNSL and fibre of outer shell of raw cashew nut inside the drum, while roasting is the major source of air pollution. Besides, the initial heating of rotating drum (used in roasting process), baby boiler (used in Cooking process), Borma Oven with Cashew nut shell as fuel also results into the air emissions.

Borma heater is also a source of air pollution. Wastewater is generated from the quenching operation of the roasted cashew nut discharged. Cooking process also discharges wastewater from the steam cooker and emits air pollutants by Baby Boiler for steam generation and Borma heater.

Shelling is the breaking operation of the quenched and cooled cashew nuts, carried out manually and the hands of workers get damaged due to CSNL. In India skilled women cracks the nuts and they use lime ash, linseed or castor oil to protect their hands, (FAO. 1969, Cashew Nut Processing, by D.C. Russel). The kernel coming from the shelling section contains a brown cover, known as 'testa', over it. To remove testa over the kernel and also control the moisture content in the kernels, they are Exposed to prolonged and controlled heating with hot air at 80 - 90 ^oC for about 9 hrs to 10 hrs in a chamber. This process is known as "Borma". The hot air is generated by indirect heating of atmospheric air over hot surface in a "Oven".

MATERIALS AND METHODS

The following seven representative units were selected for detailed study of various environmental pollution parameters :

A) Nagercoil (Tamilnadu)

1. M/s Indian Resins & Polymers, Thengemputhoor - Cooking Process
   i) Steam Boiler Emissions
   ii) Cooker Water Discharge
2. M/s Chennai Cashew Co, Edaikodu - Roasting Process
   i) Roasting Drum Emissions
   ii) Borma Heater Emissions
   iii) Quench water discharge

B) Kollam (Kerala)

3. M/s Sun Food Corporation, Kureepally - Cooking Process
   i) Steam Boiler Emissions
   ii) Borma Heater Emissions
   iii) Cooker Water Discharge
4. M/s Sun Food Corporation, Kureepally - Roasting Process
   i) Roasting Drum Emissions
   ii) Quench Water Discharge

C) Palasa - Kasibugga (Andhra Pradesh)

5) M/s Vijayalakshmi Cashew Co,- Cooking Process
   i) Steam Boiler Emissions
   ii) Cooker water discharge
6. M/s Bhagyalakshmi Cashew Co–Roasting Process
   i) Roasting Drum Emissions
   ii) Borma Heater Emissions
   iii) Quench Water Discharge
7. Palasa -Kasibugga -General Ambient Air Quality Analysis

Monitoring Methodology

The sampling and analysis of the environmental pollution parameters were conducted by following the standard methods, procedures and guidelines prescribed by Central Pollution Control Board, New Delhi (Emission Regulations – III, CPCB Publication 1985).

Air Pollution

1. Stack Emission Monitoring

Stack sampling ports were fabricated in the stacks at representative cashew nut units where the flow

parameters are stabilized using minimum 5D criteria. In some units, exiting port holes were used (which are already in use by respective State Pollution Control Boards) due to approach constraints. However velocity measurements were repeated during the period of sampling to ensure that there was not change with time. The velocities at requisite traverse points were measured by using standard pitot tube and micro manometer. The average velocity across the stack cross-section was calculated. The temperature of the gases was measured with Cr-Al thermocouple. The flue gas analysis in terms of CO_2, CO, O_2 and NOx were conducted by a direct reading flue gas analyzer by MRU, German make approved by Technische Übervachung Vereinigung (TÜV), Germany, instead of Orsat's apparatus which is cumbersome and time consuming. The instrument has electrochemical cells, which can analyze the respective gas components instantaneously and report the readings in percentage or ppm as case may be. An average of 10 minutes continuous measurement were taken and such measurements were repeated 2 to 3 times during the period of sampling and the average value is reported.Stack sampling train made by Strölein, Germany was used for particulate and gaseous sampling. The particulate matter concentrations were measured by thimble holder method under iso-kinetic sampling conditions. The sulfur dioxide concentrations in the flue gases were measured by IPA – wet chemistry method.

The phenolic compounds in the flue gases were measured by chloroform extraction method. Gas samples were absorbed in 0.1N NaOH. The absorbed air samples were reacted with 4-amino-antipyrine in presence of potassium ferri cyanide to form antipyrine dye which was extracted with chloroform. The absorbance was measured with UV spectrophotometer at 460 nm. Same analytical procedure was followed for the analysis of wastewater samples from cooker, quenching process. The minimum phenolic compounds measured in air and water samples were 0.02 mg/Nm^3 and 0.05 mg/L respectively. (APHA, 1992. Standard Methods for the Examination of Air and Wastewater Samples, 18th Edition).

Ambient Air Quality Monitoring

Ambient air quality monitoring was analyzed by installing RPM sampler of Envirotech, New Delhi make. The sampler was located on the terrace of residences in the midst of cashew nut units and measured the SPM concentration during the working and non working period of cashew nut units.

Wastewater Discharges

Since the cashew nut cooking process is a batch process, the quantity of the water discharge from the cooker per batch was collected and measured in litter per batch. The wastewater discharge from quenching of cashew nut in roasting process were collected for specific time using stop watch and the discharge rate was calculated in L/hr. Since the cashew nut process was limited only for few hours in a day, the total wastewater generation load per 100kg of cashew nut cooked was calculated. Ground water samples in and around the cashew nut processing units were also collected and analyzed to study the influence of waste water discharges by the units on the ground. All the wastewater samples were analyzed for pH, TSS, TDS, O&G, BOD, COD and Phenolic compounds (represented as phenols). The actual domestic water consumption by the units was assessed with the help of the information by the respective unit management.

Noise Pollution

Noise levels in dBA in roasting drum area, shelling section, baby boiler and cooking section, Borma operation and peeling and grading sections of the units were measured using a noise meter made by Brül and Kajer, Denmark.

RESULTS

To assess the pollution load from cashew seed processing units, the monitoring of air emissions, ambient air quality, effluent generation and noise was carried out from all the pollution generating operations i.e. Roasting Process, Cooking Process (using fuel both i.e. roasted shells and deoiled shells), Borma oven (using fuel both i.e. roasted shells and deoiled shells). The field sampling and analysis data for cashew nut Roasting units, Cashew nut Cooking units and Borma Oven are given in the Table 1. The SO_2, NOx, OH- and PM concentration from the Roasting process found to be in the range of 10-36 mg/Nm^3 , 27-131 mg/Nm^3, 2.9- 5.3 mg/Nm^3 and 665-1468 mg/Nm^3.

The SO_2, NOx, OH- and PM concentration from the Cooking process (Baby Broiler stack emission using fuel roasted shell) found to be in the range of 21-30 mg/Nm^3 , 227-593 mg/ Nm^3, 3.2- 4.3 mg/Nm^3 and 992 -1270 mg/Nm^3. Whereas the SO_2, NOx, OH- and PM concentration from the Cooking

process (Baby Broiler stack emission using fuel de-oiled shells) found to be in the range of 12-29 mg/Nm^3, 124-645 mg/ Nm^3, 0.24- 0.6 mg/Nm^3 and 382-535 mg/Nm^3.

The hot air oven is fired with Roasted shell or Deoiled caked, where the flue gases transfer the heat to the air flow over the fire tubes. The flue gases are drawn from the oven by natural draft stack. The emissions from three Borma ovens at three different units were studied. All the three ovens were fired with roasted cashew shell. The Borma oven firing continues for 4 to 6 hrs in day depending on the moisture content in the cashew kernels. The range of emission of SO_2 , NOx, OH- and PM concentration from the Borma Oven (using fuel roasted shell) found to be in the range of 10 - 48 mg/Nm^3, 55 –146 mg/Nm^3, 0.4 - 0.8 mg/Nm^3 and 405 - 587 mg/Nm^3.

Effluent Discharges

During the Roasting Process, the hot roasted nuts, in burning condition are discharged at the end of the drum and the flame is put-off by water spray. The water consumption by the spray nozzles at different units was varying between 60 - 120 L/ hr. It was observed that about 25% to 30% of water sprayed was evaporated or carried away along with the quenched nuts and the remaining water is discharged into drain. About 14 to 21 L/100 kg of cashew nut cooked of quench water discharge was measured in the quench water drain.

In the Cooking Process, the cooker waster samples from three different units were collected and analyzed for respective parameters. There are different practices with the quantity of steam injection into the cooker. In some units the steam is injected into the cooker till the steam ejection appears at the outlet of the cooker. This method gives little condensate measure to be 0.8 - 1.9 L/100 kg of cashew nut cooked. Whereas in some units the steam is injected continuously for about 10- 15 minutes even after the steam ejection appear at the outlet of the cooker. In such cooker the steam condensate quantity measured to be about 2.4- 5.0 L/100 kg of cashew nut cooked. The quench water samples and cooker waste water samples from three roasting units and cooking units were analyzed for different parameters i.e, pH, TSS, TDS, O & G, BOD, COD and phenol and range of variation is given in Table 2.

Ground Water Quality around Roasting and Cooking Units

Since the cashew nut processing units are discharging waste water on ground for years together, to assess the present status of ground water in and around the cashew nut units in Tamilnadu and Kerala states ground water samples were collected and analyzed for drinking water parameters. The analysis data are given in Table 3.

Ambient Air Quality monitoring data at Palasa Cluster Units

To assess the ambient air quality during the working and non-working period of the units, ambient air quality samples for SPM were collected in Palasa-Kasibugga area for 4 hrs each during the respective periods (Table 4). The average concentration of SPM during non-working period was about 145 µg/m^3 and the roasting period the value is as high as 607 µg/ m3. The 8hr average SPM concentration during the day time is calculated as 250- 376 µg/m^3.

Noise Levels (dBA) at different sections

The noise levels in the roasting opeation, Borma operation, Cooking Operation, Shelling / cutting and peeling sections were measured. The range of variations are given in Table 5.

Solid Waste Generation

The Solid Waste generation in Cashew Nut Processing Industries were also estimated. It was found that each bag of cashew nut (80 kg) processed either by roasting or cooking process generates about 47-50 kg of roasted shell or de-oiled cake. None of the units store these wastes as they have been used as fuel immediately or sold in the market. The 'testa' generated from the peeling section has continuous market demand where it is used as vegetable tanning agent in tanneries. The CNSL and the oil mud generated from the oil expeller units have export market in resin and paint industry. The ash generated from the initial drum heating is used in sprinkling over the roasted and quenched nut to prevent sticking. However the bottom ash from the Borma air heater and the steam boiler in the cooking process is land filled within the unit premises.

DISCUSSION

The study showed that the cashew nut industries are polluting industries, though the pollution emission load (kg/hr) by cashew nut processing, both by roasting and cooking processes, is very low even though the concentrations of particulate matter emissions and wastewater discharges viz., BOD, COD, TDS and phenolic compounds are high. The roasting and cooking processes are operating only for a small part of the day maximum 2 to 4 hrs in a day) emitting pollutants. For the remaining part of the day, the industry is not discharging any trade effluent or air emissions in to environment.

The result shows the particulate matter (PM) emissions from Roasting process is in the range of 665-1468 mg/ Nm^3 (1.3- 2.6 kg/hr) and Baby Boiler stack Emissions fired with Roasted Shell, particulate matter emissions are in the range of 992-1270 mg/Nm^3 (0.18- 0.23 kg/hr) whereas Baby Boiler stack Emissions fired with deoiled shells the particulate matter emissions are comparatively less i.e. in the range of 382-535 mg/Nm^3 (0.08- 0.1 kg/hr). More than 2.0 kg/hr (3 kg/T of raw cashew processed) particulate emission (soot) concentrations were observed when improper combustion prevails due to high cashew nut input and low gas temperatures. The unburnts and soot formation is causing high particulate matter in emissions. Phenolic compounds, reported as phenols C_6H_5OH are less than 5 mg/Nm^3 (0.01 kg/hr) in air emissions and less than 10 mg/L in wastewater batches. The sulfur Dioxide and Nitrogen Oxide emissions from the air pollution sources in the cashew nut industry are less than 0.1 kg/hr. The emission load of these parameters are very low and there are no proven technologies for control at such lower magnitudes.

The wastewater generation from cashew nut industry is of

Table 1. Air Emissions

Source of Emissions	Flow Rate of Gases NM^3/hr (CO2 %)	Temp °C	SO_2	NOx	OH- *	PM	Remarks
Roasting Drum Stack Emissions	1500-2500 (1.5%-4.0%)	135-360	10-36 (0.02-0.07)	27-131 (0.05-0.17)	2.9–5.3 (0.0005-0.01)	665–1468 (1.3-2.6)	1120-2000 raw cashew nut processed per day (2-4 hrs of operation)
Baby Boiler Stack Emissions–Roasted shell	181-182 (4.2%-5.7%)	340-367	21-30 (0.004-0.005)	227-593 (0.04 -0.11)	3.2- 4.3 (<0.001)	992-1270 (0.18-0.23)	320Kg Cashew nut processed per day
Baby Boiler Stack Emissions–Deoiled cake	193-495 (13%-14%)	340-720	12-29 0.003-0.006)	124-645 (0.03-0.1)	0.24-0.6 (<0.001)	382-535 (0.08-0.1)	400Kg Cashew nut processed per day
Borma'Oven–Emissions-Roasted shell	186-996 (1.0%-2.7%)	190-352	10-48 (0.001-0.05)	55-146 (0.01-0.09)	0.4-0.8 (<0.001)	405-587 (0.1-0.36)	About 3000Kg- 400 Kg Cashew ker-

Note : Avg concentrations are in mg/Nm^3 and values in paraenthesis are kg/hr ; * Phenol is represented as OH^-

Table 2

Sources of Water Discharge	Effluent Flow Rate	pH	TSS	TDS	O & G	BOD	COD	OH- *
Quench Process	14-21 Litre/hr	7.2–8.2	1175–2115 (0.12-0.255)	2240–4284 (0.19-0.29)	1400 – 2068 (0.13-0.25)	2000 – 5,424 (0.16-0.625)	7290 – 10,240 (1.2-2.2)	5.2 – 7.0 (0.0005-0.0007)
Cooking Process	0.8–5.0 Litre/100kg of cashew nut cooked	5.3–7.3	350–720 (0.001–0.006)	6028-13,416 (0.03 – 0.16)	24–52 (0.00002–0.00006)	2800–5000 (0.014 – 0.046)	6080–13,200 (0.045–0.098)	4.2–10.2 (0.00003–0.00009)

Note : Avg concentrations except pH are in mg/L and the values in parenthesis are kg/batch ; * Phenol is represented as OH^-

Table 3. Ground Water Quality in & Around Cashew Nut Processing Units

S.No	Parameter	Unit in Kollam			Unit in Nagercoil		IS10500 DW Standards
		1	2	3	4	5	
1.	pH	6.5	5.9	7.3	7.6	7.8	6.5 – 8.5
2.	Chlorides	22	28	80	65	20	250 - 1000
3.	TSS	42	26	15	25	15	-
4.	TDS	109	102	ND	ND	ND	500 - 2000
5.	Nitrate	1.5	3.0	19	19	42	25 - 100
6.	Phenol Compounds	ND	ND	ND	ND	ND	-
7.	Total Hardness	22	16	135	71	264	300 - 600
8.	Sulphate	10	5	44	30	69	200 - 400
9.	Iron	ND	ND	ND	ND	0.2	0.3 – 1.0
10.	BOD	ND	ND	ND	ND	ND	-
11.	COD	16	20	27	16	70	-
12.	Oil & grease	ND	ND	ND	ND	ND	-

batch type for 2 to 4 hours in a day. It is too small a quantity 200 L/day at a BOD of 5000 mg/L, COD of 10000 mg/L and Oil & Grease (Extractable, mostly in the form of phenolics compounds) at 2000 mg/L. The broad characteristics indicate high strength and of phenolic in nature. The ground water quality in and around the units indicated that the ground water quality is still not deteriorated.

The units in Kerala and Tamilnadu are bit isolated units and surrounded by well developed green cover. No deposits of dust or impact by the cashew nut unit were observed on trees and surrounding areas. The units in Palasa (Andhra Pradesh) are developed as a cluster surrounded by residential houses. Once all the units start operation simultaneously, there is visible build up of smoke in the atmospheric air. It is suggested for such clusters to change roasting process into cooking process Each unit requires about Rs. 10 lakhs for changing the process method from roasting to cooking process. The Central Govt. has recently announced a subsidy scheme in this regard under which it is offering Rs. 10 lakhs to each unit, of which subsidy component is Rs. 2.5 lakh while Rs. 7.5 lakh is towards tax concessions. The cashew manufacturers in Palasa, the largest Cashew market in Andhra Pradesh are gradually switching to boiler cooking from traditional drum roasting system. (Source: Business standard, Palasa Cashew Units focus on curbing pollution). The study reveals that noise pollution is not an issue associated with the cashew nut processing Industry.

CONCLUSION

It is revealed from the study that the cashew nut industries are polluting industries. To reduce the emissions from Roasting Process high efficiency control systems like wet scrubbers are required. Considering the high temperature or corrosive nature of fumes, wet scrubbers are the right "end of pipe pollution control" choice (Waste Audit and Evaluation of Process Technologies for Cashew Nut Industries at Palassa Srikakulam district). Thus the particulate emission upto150 mg/Nm^3 is achievable (90%-95% dust removal efficiency) by installing Venturi Scrubber dust control system for Roasting Process (2-4 hrs of operation & 560-640 Kg/hr of cashew nut processing). Investment cost of which shall be about Rs. 2.5 lakhs. It is also suggested that the dog house emissions are to be directed together with the roasting drum emissions to wet scrubber to

Table 4.

Cashew-nut industry operation	Suspended Particulate Matter Concentration, µg/m^3			
	> 10µ 4hrs Avg	RSPM < 10 µ 4hrs Avg	SPM 4hrs Avg	SPM 8hrs Avg
In operation (Upwind)	221	133	354	
Not in operation	40	106	146	250
In Operation (Down wind)	27	580	607	
Not in operation	46	99	145	376

Table 5.

Roasting Drum	Shelling	Cooking Operation	Cutting	Borma Operation	Peeling & Grading
81 - 85	80 - 83	78.7 – 81.0	80 - 82	73 - 75	68 - 70

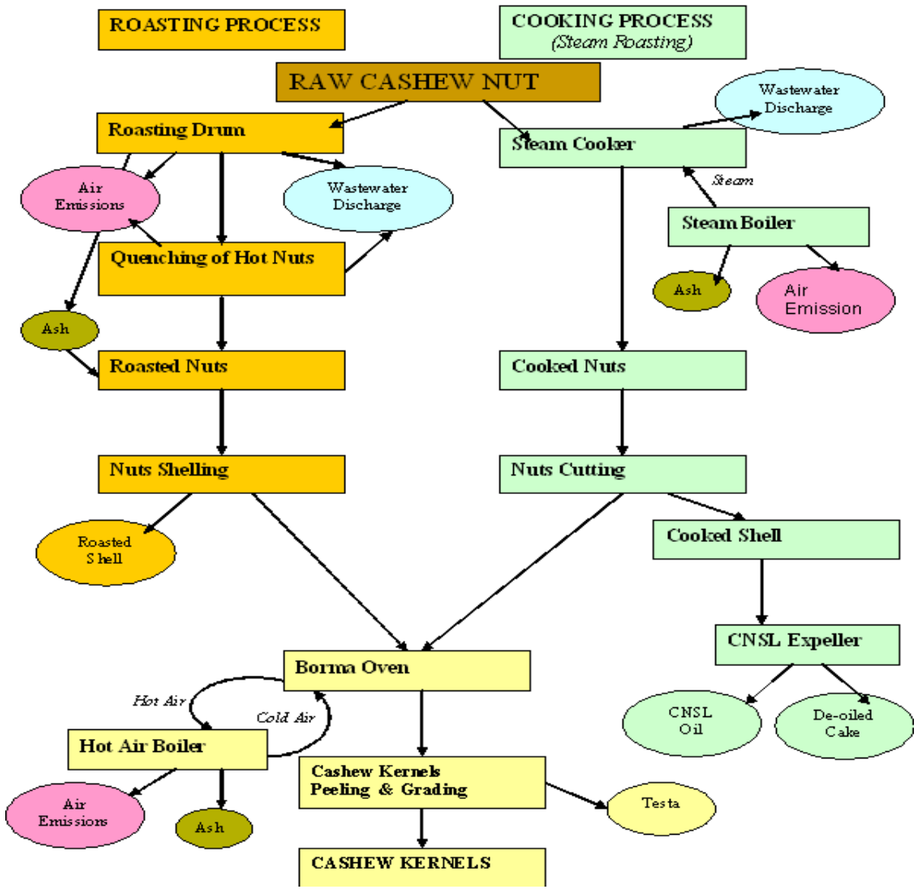

Fig. 1 Cashew nut processing &discharges to environment

bring down the emission level (COINDS/75/2007), from the Roasting units during operation. The periodic wastewater discharge from Venturi Scrubber is to be treated together with quench water discharge. Since both the air heater in Borma operation and the steam boiler in cooking process are manually fired with natural draft stack with similar firing practices and the fuel firing is intermittent and batch type, it is not practicable to implement any scrubber. The emissions reduction from 1270 mg/Nm^3 to 150 mg/Nm^3 without any control system is not practicable. Hence, in such a scenario, emissions from Cooking Boiler and Borma operations can be minimized by using only deoiled cake for firing instead of roasted shell or the units have to install biogasifiers to achieve the emission level upto 150 mg/NM^3(4-6 hrs of operation). The emission level of sulfur Dioxide, Nitrogen Oxide and phenolic compounds can be minimized with sufficient stack heights, i.e. 20 m from ground level for Roasting Process and 15 m from ground level or 2 m above the height of the nearest building whichever is higher for Cooking process and Borma Oven Heater. The stack heights are more than adequate for better dispersion of these pollutants into atmosphere.

Alternatively the cooking (steam roasting) process, which is relatively less pollution intensive and an alternative process to roasting process may be adopted by the Cashew Nut Processing Units

To minimize the water pollution and to comply with the surface water discharge standards, which can be reused for gardening the two alternate treatment methods i.e. **Alternate – 1 :** A typical SBR (Sequential Batch Reactor) system and **Alternate – 2 :** Rotating Biological Disc Treatment can be adopted. The SBR system will consist of ; Collection-cum-aeration-cum-settling tank; Sand Bed Filter system for decanted water filtration and Sludge drying bed for excess sludge .The investment cost of SBR will be Rs 4.5 Lakhs. Rotating Biological Disc Treatment, system consist of: Buffer tank, integral part of packaged plant ; Feed pump of Water Wheel type connected to the RBC Drive itself; Sludge disposal timer operated pump and Sludge drying bed for excess sludge. The investment cost of RBC is Rs 4 - 5 Lakhs.

For solid waste disposal, i.e. ash generated at the bottom of Borma air heater as well as the Steam Boiler should be properly land filled with necessary precautions so that there are no secondary air emissions. It is suggested that the cashew shell generated especially by roasting process, presently used as fuel by the industry, should go through bio gasification route to convert in to less polluting fuel gas as a long-term measure.

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