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Traditional lime preparation-A case study in coastal Orissa, India

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The present paper describes the indigenous method of lime preparation in coastal Ganjam district, Orissa. Molluscs shells such as *Anadara granosa* (Khola), *Meritrix meritrix* (Gondhi), *Meritrix casta* (Pati) and *Cerithidea cingulata* (Genda) were mainly used for lime preparation. Average annual consumption of shell in wet lime and powder lime units was 89 Mg 208 Mg, respectively. For preparation of 100 kg wet lime and powder lime average consumption of shell were 48 kg and 117 kg, respectively. Per burning, average production of wet lime and powder lime was 1.423 Mg and 0.553 Mg, respectively. Annual production of wet lime was 197.6 Mg and powder lime was 180.4 Mg per unit. Inanimate energy expenditure in wet and powder lime units was 986 and 3120 GJ (average), respectively, while animate energy consumption was insignificant. Conservation of this traditional technology of lime preparation is suggested.

Keywords: Dry lime, Marine mollusc shell, Traditional lime preparation, Wet lime, Orissa
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Lime (Calcium oxide) is produced from a sufficiently pure sedimentary rock (lime stone) or shells of some marine molluscs. The lime produced from the shell of molluscs is locally known as *Sipo chuna*. The term lime refers to both quick lime and hydrated lime. Quick lime is produced by heating the mollusc shell or limestone to its dissociation temperature, while hydrated lime is the product obtained by the reaction of quick lime with water. If more water is added, the result is lime putty, some times called *Milk of lime* and locally called *Dahi chuna.* Ganjam, one of the coastal districts of Orissa is famous for its lime industry. Shell lime forms an important item for white washing, in preparation of *Gudakhu* (a paste of tobacco leaf, lime and some sweetening agent), *Nasa* (snuff powder of tobacco leaf and lime) and *Khoini* (tobacco leaf and lime). It is also used in *Pan* (betel leaf, lime and other ingredients), as an agent to increase the alkalinity of fishponds, as water purifier in dug wells and for hygienisation of sewage sludge[1]. It is also used in preparation of cement and bleaching powder.

No ecological work on shell lime industry is available in India. However, some ecological work including energetic on *Gur* (jaggery) industry and country liquor distillation units of Ganjam district, Orissa has been reported[2-3]. Some research reports on energy expenditure in agriculture and in the forest sector are available[4-7]. There are some references to shell lime industry and types of shell used for lime preparation in Orissa, but no systematic and detailed studies on shell lime preparation from mollusc shell have been reported so far in India[8]. An attempt was undertaken to study the traditional technical know-how involved in lime preparation from mollusc shells, to estimate the animate and inanimate energy involved in preparation of lime and its final supply for use, and to suggest means and methods to improve the efficiency of lime production and its environmental impact.

Methodology

The overall method includes both laboratory work and survey carried out with the help of a special questionnaire-cum-schedule. For the present study, 8 lime processing units present in and around Berhampur city (19° 16′ N and 84° 53′ E) of Ganjam district, Orissa were selected (Fig. 1). Each unit was visited frequently every month. The method of washing, mixing, burning, slaking and packing was observed regularly. The owner and workers of each unit were approached several times and necessary information regarding time spent for different activities and the amount of shell and charcoal utilized, were obtained by filling the questionnaire. The amount of shell and charcoal required per

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burning and the amount of lime produced for each type of shell was recorded from 5 different burnings by weighing the materials. From this, the average production per burning was calculated. The number of burnings for different types of shell and the total number of burnings of each unit in every month were noted. The total amount of different types of shell and charcoal consumed every month was calculated by multiplying the number of burnings with the respective quantities per burning. Data on articles used for both short and long periods were collected.

As there is neither any instrument nor any direct method available to measure the human energy expenditure, it was estimated following standard practice[9]. The energy expended in different activities such as burning, slaking, and packing was derived by the following procedure. The total time spent by an individual per burning was recorded and this was multiplied by the number of workers engaged to calculate the total time utilized per burning. The total time spent for lime preparation in different units during different months was calculated by multiplying the time spent per burning with total number of burnings in different months. The total human hours spent was converted to energy by multiplying with the standard conversions[9]. The energy content of diesel, kerosene, bamboo, rope (coir) and charcoal were arrived at by multiplying the respective unit weight/volume with appropriate energy equivalents (Charcoal: 30 MJ kg^{-1}; Diesel: 14.16 MJ l^{-1}; Kerosene: 35 MJ l^{-1}; Bamboo: 15.83 MJ kg^{-1}; Coir rope: 20.83 MJ kg^{-}); Electricity: 3.58 MJ kwh^{-1})[6,12-14].

Results

The lime production units consisted of two main components - the burning unit and the slaking pit (*Kunda*). However, the powder lime-producing units had no slaking pit (*Kunda*). The burning unit had three main parts, the kiln (*Bhatti* or *Chula*), the fan, and the wheel. The kiln was specially designed for burning of mollusc shell. It was constructed in East-West direction to facilitate proper ventilation. The kiln was a dug well like structure, circular in shape, made up of bricks and mud (clay) (Fig. 2). It was 90 cm deep with a diameter of 1.75 m at the mouth, and the width of the kiln wall was 15 cm. The kiln depth, however, varied from unit to unit. The base of the kiln was 20 cm above the ground, to facilitate the flow of air that was supplied by a fan through a small inlet. The junction of the fan and the kiln was made airtight with clay. The base of the kiln had a passage 80 cm long and 15 cm wide, on which iron rods were arranged parallel to the ground in such a manner that it did not allow the shells and charcoal to fall. The fan was fitted on a 40 cm high, 90 cm long and 45 cm wide wooden stand with a tin cover. This tin covering had a narrow outlet that connected with the small inlet of the kiln for air supply. The fan had 5-7 blades and an axle, which was connected with a wheel of radius 70 cm with the help of a rope, in such a way that when the wheel was rotated the fan also rotated, simultaneously. The fan was fitted at a distance of 35 cm from the kiln. The narrow outlet of the fan was fitted into the kiln inlet. The wheel had a handle to rotate it and was fitted on a wooden stand 1 cm high (Fig. 2). The distance between the fan and the wheel was 3.35 m and the two were connected with a coir rope 6.75 m long. In some units, electrical fans replaced traditional fans. Each unit had 2 rectangular slaking pits (Fig. 3). The pit was 2 m long and 1m wide on its inner side, and 1-1.5 m deep. The walls of the pit were made of cement and brick.

Lime preparation was done with the help of skilled and experienced persons who had sufficient knowledge of the techniques of shell burning, slaking and packing. Lime was carefully handled, as it is very corrosive to human skin. Burning of shells was done with the help of charcoal. The shells and charcoal were thoroughly washed with water and were mixed in a ratio of 2:1 by volume for lime putty and 1:1 by volume for dry hydrated lime (powder lime). To start with, one layer of charcoal was spread at the base of the kiln, and ignition was done with the help of straw and kerosene. Air was supplied from the fan through the inlet of the kiln by rotating the wheel. Then the first layer of the mixture of shell and charcoal was spread and the process was continued till the kiln was full. At each interval the mixture was loosened with the help of an iron rod and air was continuously supplied. In this type of traditional kiln the temperature was maintained at about 900^0 C[10]. By continuous air blow, the ash was blown out of the kiln at each step. During different stages of loading the shell mixture, some extra amount of charcoal was also added to maintain the temperature of the kiln. The entire process for a single burning took around 3-4 hrs.

After the shells were completely burnt, they were left in the cavity of the kiln for about 30 min to cool, then transferred to the pit containing water and stirred with the help of an instrument locally called *Katua*

(Fig. 3). Stirring was continued till all the shells were mixed with water to produce lime putty, which was then packed into polythene bags (Fig. 4). To prepare dry hydrated lime, the burnt shells were piled into 4-6 heaps, each containing 8-10 tins (of 15 l capacity) of shell. Each heap was sprinkled with water and mixed thoroughly with the help of a spade or shovel so that each shell could come into contact with water and become powder (Fig. 5). The unburnt shells and other impurities were separated with the help of a sieve (C*haluni*) (Fig. 6), and were again burnt, slaked and cleaned, leaving some waste materials.

At Berhampur, 6 types of mollusc shells were utilized for the preparation of lime. They are– bivalves: (i) *Anadara granosa* Linn. (Granular Ark shell) locally called *Khola sipo*, (ii) *Meritrix meritrix* Linn. (Bay Calm) locally called *Gondhi sipo*, (iii) *Meritrix casta* Gmeblin locally called *Pati sipo*, (iv) *Sunetta* sp. Gastropods: (v) *Cerithidea cingulata* Gmeblin (Cerithid Snail) locally called *Genda* and (vi) *Telescopium telescopium*. Out of the above species, 4 species, viz., *Anadara granosa* Linn., *Meritrix meritrix* Linn., *Meritrix casta* Gmeblin and *Cerithidea cingulata* Gmeblin were used in large quantities while the use of the other 2 species was insignificant[11].

Out of the 8 units (Fig. 1), 6 units were engaged in wet lime production and 2 were engaged in powder lime production. Of the 4 types of shells used during the year in the wet lime units, the utilization of *Khola* ranged between 15.7-40.0 Mg. The lowest and highest consumption of *Pati* was 10.2 and 17.6 Mg. Similarly, maximum (52.2 Mg) and minimum (19.4 Mg) amounts of *Gondhi* were used in units 1 and 4, respectively. In the powder lime units the highest amount of *Khola* was used in unit 7 and *Gondhi* in unit 8. The trend of utilization of mollusc shell used (average) for wet lime preparation was: *Gondhi*> *Khola*> *Pati*> *Genda* and in powder lime it was: *Khola* >*Gondhi* (Table 1). The percentage of consumption of different types of shell in the different units is shown in Fig. 7. Among wet lime units, the utilization of charcoal varied between 42.8 and 20.9 Mg, while it varied between 76.8 and 136.4 Mg (Table 1). Total number of burnings in the wet lime and powder lime units varied from 92 to 175 and 261 to 377, respectively[11]. For a comparative study of the units, the consumption of shell and charcoal per 100 kg of lime was estimated. In wet lime units, the shell consumption ranged between 35 and 67.2 kg and charcoal between 12.9 and 25.8 kg for production of 100 kg of wet lime. In powder lime units, shell consumption for 100 kg of lime was 112 and 121 kg and charcoal consumption was 57.9 and 61.3 kg (Table 2).

Materials such as bamboo basket, coir rope, oil tin, polythene bags and pin which were used in the units were annually renewed while other materials such as *Katua*, weighing balance and spade were used for a longer time. The quantity of materials used in the units varied depending on the number of burnings[11]. Production of wet lime per burning ranged between 1010 and 2238 kg. Average production of powder lime per burning was 553 kg. Total annual wet lime production in the units varied between 107.1 and 302.2 Mg while in powder lime units it ranged between 235.6 and 125.3 Mg. Total annual waste production was 19.6 Mg and 20.9 Mg in units 7 and 8 respectively (Table 3). The time spent and the energy expended by men and women labourers per burning varied in different units depending upon the number of workers engaged. Total human energy expended (46.9 MJ) was highest in units 2 and 3, and lowest (20.1 MJ) in unit 7 (Table 4). Out of the total energy expended in the wet lime units, men shared between 33.3 % to 50 %, while in the two powder lime units the share ranged between 67 % and 40% [11]. Total annual energy expenditure by the owners varied between 231 MJ and 848 MJ in the wet lime units, and between 947 and 1311 MJ in powder lime units[11].

Energy utilized through different materials is depicted in Table 5. The energy utilized through charcoal, which was the main component for burning varied between 724 and 1285 GJ in the wet lime units, and was 2304 and 4092 GJ in powder lime units 7 and 8, respectively. The energy utilized through accessory materials such as bamboo basket and coir rope varied in different units. Highest energy was utilized through bamboo basket in wet lime and powder lime units. Total biomass energy utilized varied between 628 and 1286 GJ in wet lime units and between 2305 and 4094 GJ in powder lime units (Table 5). Non-biomass energy utilized through kerosene, which was used for ignition, varied between 0.42 and 0.84 GJ. Electrical energy was used in powder lime unit 7 (0.32 GJ) to run the fans and in unit 8 (0.11 GJ) for lighting (during early mornings). Total inanimate energy expenditure in wet lime units varied between 629 GJ and 1286 GJ and in powder lime units between 2305 and 4095 GJ (Table 5). Total animate energy

Table 1—Different type of shell and charcoal used in burning in the units at Berhampur, Orissa

Lime units	Amount consumed (Mg) Shell type					Total Charcoal
	Khola	Pati	Gondhi	Genda	Total	
1	40.04 (52)	16.15 (19)	52.20 (58)	14.07 (15)	122.46 (144)	42.83
2	28.00(40)	16.83 (22)	48.67 (59)	12.15 (14)	105.66 (135)	38.90
3	33.39 (45)	17.58 (22)	45.37 (55)	10.92 (13)	107.26 (135)	41.63
4	15.75 (25)	10.20 (15)	19.44 (27)	9.07 (12)	54.46 (79)	20.89
5	30.87 (49)	--	41.04 (57)	--	71.91 (106)	27.64
6	16.10 (23)	15.30 (20)	40.62 (49)	--	72.02 (92)	24.15
Mean	27.36	12.68	41.22	7.70	88.96	31.67
7	263.9 (377)	--	--	--	263.90 (377)	136.40
8	67.20 (120)	--	84.60 (141)	--	151.80 (261)	76.80
Mean	165.55	--	42.30	--	207.85	106.60

Data in parentheses indicate number of burnings

Table 2—Amount of shell and charcoal required to produce 100 kg of lime in different units

	Amount (kg) Wet lime units							Powder lime units		Mean
	1	2	3	4	5	6	Mean	7	8	
Mollusc shell	42.61	34.96	49.91	46.17	67.17	46.04	47.81	112.00	121.17	116.58
Charcoal	14.90	12.87	19.37	17.71	25.82	15.44	17.68	57.89	61.30	59.59

Table 3—Average production of line per burning and total annual production in different units of Berhampur, Orissa

Units	Product per burning* (kg)			Total annual production (Mg)	
Wet lime	Lime	Waste		Lime	Waste
1	1995.6 ± 5.04	-		287.4	-
2	2238.6 ± 2.2	-		302.2	-
3	1592 ± 7.52	-		214.9	-
4	1493 ± 11.6	-		117.9	-
5	1010 ± 3.54	-		107.1	-
6	1700.6 ± 3.37	-		156.4	-
Mean	1423	-		197.6	
Powder lime					
7	625 ± 8.5	5	2.6		
8	480 ± 11.4	2±	3	235.6	19.6
		8	3.5		
		0±3		125.3	20.9
Mean	553	66		180.4	20.2

*Average of 5 bumings ± SEM

expenditure for production of 100 kg of wet lime varied between 2.23 and 3.21 MJ, average being 2.74 MJ. Inanimate energy expenditure ranged between 387 and 775 MJ with an average of 531.5 MJ, while total energy expenditure varied between 778.9 MJ and 389 MJ, the average being 534 MJ. Energy expended to produce 100 kg of powder lime requires on an average 1295 MJ, of which human energy was negligible (6 MJ).

Discussion

The method of lime preparation adopted in this area is purely indigenous and has not been documented so far. This indigenous knowledge of kiln construction, shell burning and lime preparation has been transmitted from generation to generation and over the years the techniques have been perfected. It was observed that in all the units, the same techniques and standards were used. The wall of the kiln was made up of brick and mud because earthen wall can tolerate high temperatures of about 800-900 °C.

Production of lime was affected mainly by shell and charcoal availability, number of burnings and market demand. The variation in the quantities of shell burned in different units during the year was due to differences in the capacity of the kilns and type of shells used. The proportion of shell and charcoal for burning was almost constant depending on the type of lime produced. The amount of charcoal used varied depending on the type of shell used. The highest amount of charcoal was used for *Khola* (*Anadara granosa*) due to its thick and large shell size. Burning of *Gondhi* (*Meritrix meritrix*) and *Genda* (*Cerithidea cingulata*) consumed more charcoal than *Pati* (*Meritrix casta*) due to their hard and compact shell. The capacity of the kiln cavity also affected the rate of charcoal consumption. In smaller kilns, the

Table 4—Total time and energy spent by workers per burning and during the yar in different lime units and Berhampur Orissa

Lime units	No of workers		Energy expended per burning (MJ)			Annual energy expenditure (MJ)		
	Men	Women	Men	Women	Total	Men	Women	Total
1	2	4	13.4 (16)	26.8 (32)	40.2 (48)	1929	3858	5787
2	3	4	20.1 (24)	26.8 (32)	46.9 (56)	2712	3617	6329
3	3	4	20.1 (24)	26.8 (32)	46.9 (56)	2712	3617	6329
4	3	3	20.1 (24)	20.1 (24)	40.2 (48)	1587	1587	3174
5	2	2	13.4 (16)	13.4 (16)	26.8 (32)	1420	1420	2840
6	2	4	13.4 (16)	26.8 (32)	40.2 (48)	1232	2465	3697
Mean			16.7	23.45	40.2	1932	2760	4692
7	2	1	13.4 (16)	6.7 (8)	20.1 (24)	5050	2525	7575
8	2	3	13.4 (16)	20.1 (24)	33.5 (40)	3496	5244	8740
Mean			13.4	13.4	26.8	4273	3884	8157

Figures in parentheses indicate hours

Table 5—Annual inanimate energy expended in different units at Berhampur, India during 2003

Lime Units	Biomass energy (GJ)				Non-biomass energy (GJ)			Total inanimate energy (GJ)
	Charcoal	Bamboo basket	Coir rope	Total	Kerosene	Electricity	Total	
1	1284.9	0.65	0.37	1285.92	0.42	-	0.42	1286
2	1167.0	1.55	0.25	1168.81	0.84	-	0.84	1169
3	1248.90	1.55	0.12	1250.58	0.42	-	0.42	1251
4	626.70	1.30	0.08	628.08	0.63	-	0.63	629
5	829.20	0.78	0.10	830.08	0.42	-	0.42	830
6	724.50	0.39	0.08	724.97	0.42	-	0.42	725
7	4092.00	1.62	-	4093.62	0.84	0.32(90.5)	1.16	4095
8	2304.00	0.78	0.25	2305.03	-	0.11(31.3)	0.11	2305

temperature of which comes down quickly, more charcoal was used in different stages of burning to maintain the temperature. In powder lime units, the charcoal and shells were in equal ratio by volume because they had to burn the shells for a longer period. The quality of charcoal also played an important role in regulating the amount of consumption. Quality of charcoal depends on the type of wood from which charcoal was extracted. However, no study has been made on the quality of charcoal used in the units. Lime production is influenced to some extent by the supply of charcoal, which is controlled by many factors.

The charcoal is collected from *Kewda* and liquor distilleries set up in the coastal areas and from forest wood burning in the interior areas. In the coastal area mostly they consume wood of *Casuarina equisetifolia* Linn. as fuel. Rate of production of lime putty depends on the type of shells utilized and the amount of water mixed at the time of slaking. Therefore, wet lime production differs in different units per unit raw material. In powder lime industry, the production of powder lime and waste material depends on the number of burnings of the same sample. Production of wet lime was more during September and October to meet the market demand for lime for white washing houses, which went up during this time, as there were more festivals and ceremonies[11]. At times, unusual and sudden rains during shell burning caused a great deal of damage to lime production because the kilns and slaking pits were set up in the open. It was observed that shell lime putty could be stored for longer periods than stone lime. The stone lime becomes hard after 2-3 weeks but shell lime putty remains as such for at least 2 months. Although large amount of human energy was expended for the production of lime, the inanimate energy expenditure was much more than the human energy as charcoal was the main component for burning. The production of powder lime per burning was less as compared to wet lime hence energy expenditure for unit weight of lime production becomes high.

In urban areas demand for lime putty is decreasing, as people prefer to use other materials (distemper)

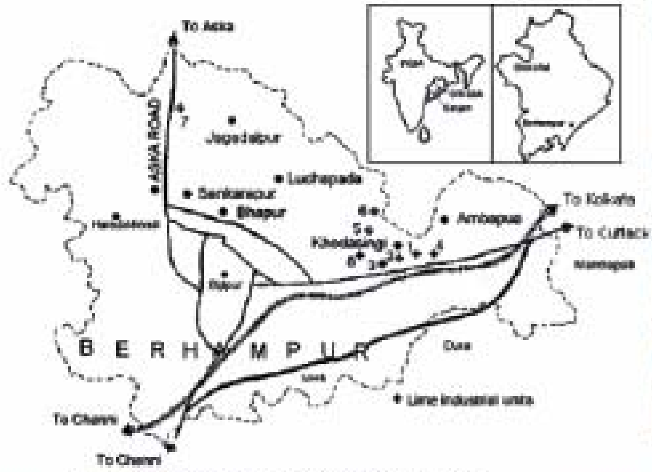

Fig.1 Location map showing study area


Fig.2 General view of the kiln (*Chula*)


Fig.3 Stirring of lime during slaking


Fig.4 Packing of wet lime


Fig.5 Slaking of powder lime


Fig.6 Sieving of powder lime

rather than shell lime. Moreover, powder lime prepared from limestone is also available in the local market. On the other hand, the demand for powder lime is increasing because of its use in the preparation of *Gudakhu*, *Snuff* and *Khoini*, which are more in demand. However, in powder lime industry only the *Khola* and *Gondhi* types of shell are used because the lime produced from other shells is very corrosive and can damage the mouth cavity. In shell lime industry, no waste is produced in wet lime preparation while a small quantity of waste is produced in powder lime preparation. The wastes are used for cleaning ponds, flooring of poultry farms, line tracking and other purposes. The traditional limekilns produce some air polluting gases, but this is negligible as the gases are released in very small amounts and are diluted in the air. The ash produced from charcoal and the dusts of powder lime remain as suspended particulate in the

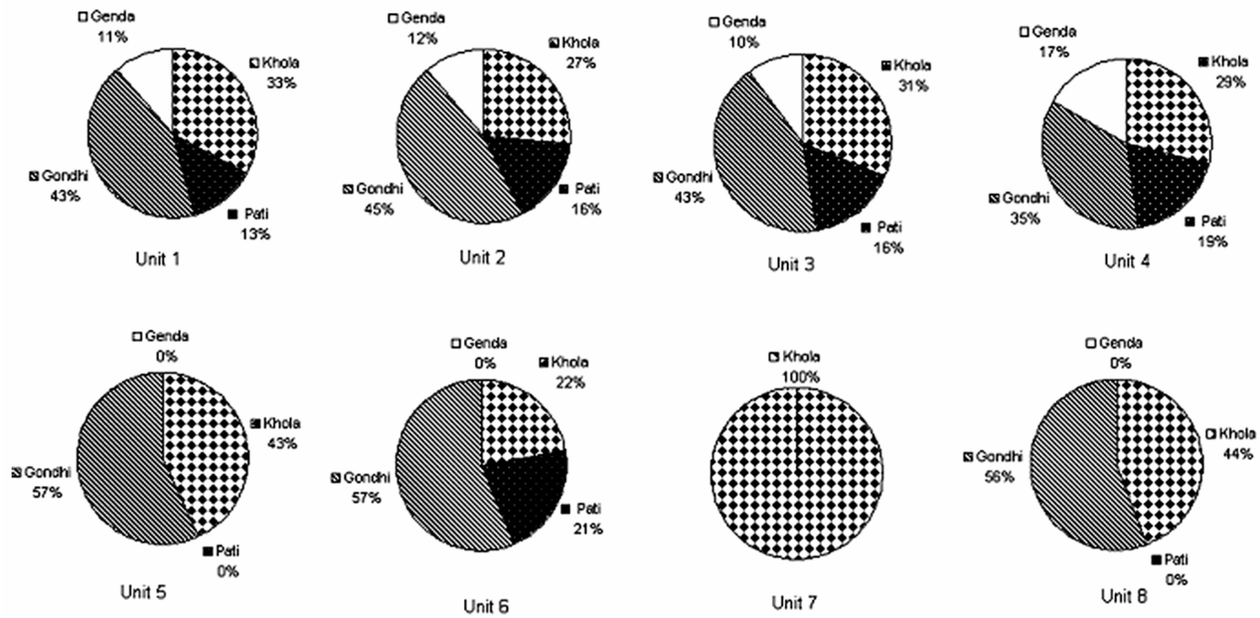

Fig. 7—Consumption of various types of shells by different units at Berhampur, Orissa

air, and are subsequently deposited in the surrounding area.

Conclusion

The technique involved in the manufacture of lime from marine mollusc shells is indigenous and crude, and can be improved through the application of modern technology taking into consideration the ecological factors. As lime is an important product, proper care should be taken to improve the lime industry and shell collection, which is presently in a neglected state. Sustainable collection of varieties of marine mollusc shells suitable for commercial lime preparation should be promoted in the area to provide better economic returns to the local people. However, care should be taken to restore the ecological condition of the area as far as possible. Unlike stone lime, wet lime is renewable and sustainable, and proper care should therefore be taken for its sustainable production. Moreover, this ecofriendly traditional technology should be conserved and maintained.

Local people who are engaged in shell collection and lime preparation should be made aware of the importance and value of their work. For the proper management of the lime industry, data on lime production and consumption, which is presently not available in the country, must be collected and analyzed. Presently, the kilns are situated near or inside the human settlements. Some had originally been built outside the settlements but are now surrounded by houses. These units should be shifted to other areas away from the settlement as they pollute the air to some extent. Unlike stone lime, shell lime is renewable and sustainable, therefore proper care should be taken for its production. Moreover, this ecofriendly traditional technology should be conserved and maintained.

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