

Physical, Chemical and Environmental Parameter of Glue Manufacture in Bangladesh

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Abstract: The study purpose to know the physical, chemical and environmental parameter of glue manufacture in Bangladesh. The existing management system of tannery solid wastes and its consequences were investigated through field survey with structured and unstructured questionnaire; the tannery workers, technologists, officials were interviewed during 2009-2011. The maximum amount of solid wastes generated was measured in the peak season (October-December) in the year 2011 through developed formula and found 443 metric ton solid wastes were generated in a day from tannery at Hazaribagh, Dhaka. It was also observed that 90% of the trimmers, (tannery workers) were directly affected by those solid wastes, the surrounding environment became polluted and soil of dumping ground was contaminated with organic carbon ($7.97\% \pm 0.170$), organic matter ($13.70\% \pm 0.292$), TKN ($1.54\% \pm 0.137$), Chloride ($0.247\% \pm 0.0284$) and Chromium (2.28 ± 0.0291).

Keyword: Physical, Chemical, Environmental, Glue manufacture, Bangladesh

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I. Introduction

Bangladesh is densely populous country. The overall economic development of the country mainly depends on agriculture, industry, and trade and service sectors. The industrial blooms were come together in contributing to the national economy of the country from the mid seventy's when Jute and Leather industries in Bangladesh were developed on a large-scale basis. Previously, the leather industries especially tanneries were owned by Bangladeshi Traders from the Punjabi and Madraji traders after liberation war in 1971 while there were some tanneries owned by Bangladeshi people as well. The 350 numbers of industries were running with new management and tried to renovate across the country. Manufacturing of leather and leather goods produce high amount of wastewater, solid wastes and volatile emission containing different loads of pollutants. As a result, the leather industry as a whole is under critical condition, needs to review by the environmentalists throughout the world. There is no exception for Bangladesh. Toxic gases such as ammonia, acid vapour, hydrogen sulphide, sulphur dioxide, carbon dioxide chlorine etc. are also produced in different steps of leather production. In fact, there is no chemical which is absolutely devoid of any harmful effect to the environment, plant, animal and human health; the variation is in the use of doses and the degree of toxicity and/or harmful effect of the reagents used in the process. There is no single process for producing leather without generating huge amount of wastes. Some of the wastes will arise from surplus, spent or washed-out chemicals used in the process. Some chemical constituents may be toxic while others are powerful pollutants in water and on soil. The release of volatile sulphides contributes obnoxious and toxic odours. Certain solvent vapours can have adverse health effects after prolonged exposure. The solid wastes generating from leather processing consists of raw trimmings, hair & wool, flashings, wet blue trimmings, splitting, shaving dusts, buffing dusts, dyed trimmings, salts, lime sludge etc. 98 MT solid wastes were generated every day from the tanneries of Bangladesh. According to the SHED Report (2002) and UNIDO Report (2006), about 89% of the tannery worker suffered from general illness. They need to take medical treatment sometimes and thus they are getting looser in their income. Therefore, the cost of human health impacts on the cost of living and their social status are evident due to income loss in absentia, loss of working hour, loss of efficiency, saving loss for the treatment and taking medical attention and occurring malnutrition resulting poor health of the earners and their family members. Sykes [1] indicated some areas in which the leather industry would need to direct technical resources, not necessarily to improve its product, but to comply with social demands which might frequently have the support of legislative action; he also said that essentially industries used resources wastefully and with little thought for the future as well as it contaminated the environment with the by-products of its operations and was therefore uncaring of people. (Islam[2], Kaisar [3], Rahaman[4]) reported that the untreated liquid and solid

wastes of tannery were discharged directly through the roadside drain and deposited to the nearby low lying areas and finally fallen to the river Buriganga which were spreading the environmental pollution. Mondal also did the repeated work and showed the environmental impact of the City Protection Embankment at Hazaribag; as he found the sluice gate remain closed year after year and huge waste and garbage discharged from the tanneries remain stagnant at the upstream and the low lying lands from Lalbagh to Rayer Bazar Shikder Medical College which were filled with those poisonous wastes resulting the land fertility was destroyed and the grass and shrub got faded and stained [5]. Yousuf did the work repeatedly. But nobody showed the data on the exact amount of solid wastes discharged from the leather manufacturing industries and the way of mitigating pollution [6]. Springer concerned about tannery solid wastes and classified it as Hazardous, Non Inert, and Inert with characteristics of Inflammability, Corrosiveness, Reactivity, and Toxicity; he also enlisted the possible utilization of it by following IULTCS compilation of by-products. His work was outstanding and showing the actual possibility of utilization of solid wastes but he did not mention the procedure of by-product production [7]. Brown et al., were first to develop the process to extract protein hydrolysate from contaminated leather waste. He extracted gelatin from chromium leather wastes subsequently developed a two-step process that allowed a protein product to be isolated in the first step followed by a lower molecular weight, hydrolyzed protein product obtained enzymatic treatment of the remaining chrome sludge, a recyclable chromium product was also obtained. But he was considering only the chrome sludge containing chrome shaving dust and trimmings [8]. Rose et al. mentioned the uses of collagen contained in hides and skins as an adhesive as well as they highlighted on the use of collagen in food, cosmetics and brewing industries. This was a hypothetical attempt to use tannery solid wastes by converting it to animal glue and other products but did not mention the process of conversion clearly [9]. Puntener first published the tanner's responsibility for active environmental protection was being assigned more and more importance in the society. He mentioned that the reduction of pollution in tannery waste was being tackled on three fronts, such as, tanneries were optimizing and reducing their overall chemical consumption and improving waste-water purification; tanneries were more efficient in their use of chrome and were selectively employing non-chrome procedures; and lastly, recycling of leather production waste was being more actively promoted. This paper also presented simple environmental balance scheme and showed a new tanning system which supplements existing tanning procedures [10]. Rutland introduced different phenomenon of waste disposal and leather manufacturing. He suggested making all process of tannery be eco-efficient or environmentally conscious, which was reached by the delivery of competitively, priced goods and services that satisfy human needs and bring quality of life, while progressively reducing ecological impacts and resource intensity throughout the life cycle to a level at least in line with the Earth's estimated carrying capacity. [11] (Lewis [12], Kumaraguru et al., [13] described about the utilization of the lime fleshings for making tallow or extracting amino acids and free fatty acids; continually, Cantera et al., [14] also mentioned another possible way of using hair for felt manufacturing, organic fertilizer, biogas generation, regeneration of keratin, recover melanin for manufacturing sun-block lotions, manufacturing of nylon 6.6, etc.; Erickson [15] stated about the alkaline hydrolysis process of chrome shaving dust for extraction of amino acid solution which could be used as a new raw material in powder form for animal feed manufacturing, fish feed manufacturing, foam enhancer, etc.; Tayloret al., [16] also discussed about the protein recovery from chrome shaving dust with cost estimation. Finally, Bossche [17] discussed about the uses of incineration for burning of chrome containing sludge and Reutlingen [18] described about the legislation governing tannery solid wastes as feed for animals and toxic sludge for disposal as land fill. Shelly et al., did research work on making Gelatin from wet blue shavings by protein hydrolysis method; Chen et al., [19] also mentioned about the hydrolysis process for protein extraction; Bowden described the conversion of tannery solid waste materials into useful energy like biogas; Crispim et al., [20] also stated the biogas production from tannery solid wastes; Bitisli et al., [21] experimented on using fleshing and vegetable shaving wastes in production porous brick; Puig et al., [22] first suggested about the separate leather estate for all through controlling pollution; Galarza et al., [23] also suggested to control pollution hypothetically. The study aims to know the physical, chemical and environmental parameter of glue manufacture in Bangladesh.

II. Materials and method

As the study was related with utilization of tannery solid wastes converting to glue, it required extensive field work for collecting data, experimental work for modifying glue manufacturing process which should not make any harm to our environment on trial and error basis, and laboratory work for analyzing soil, effluent, and the quality of glue produced from the wastes. Thus this study was the combination of experimental research and applied research consisting field survey, analytical works and technological modification. The analytical part of the study was carried out at Institute of Environmental Science (IES), University of Rajshahi and Bangladesh Council of Scientific and Industrial Research (BCSIR) Laboratory, Dhaka. Moreover, the modified method of glue production was followed in the bulk production of animal glue which was carried out

in a glue manufacturing factory adjacent to the tannery, M/S. Kalim Leathers located at Hazaribagh. A total of 60 acres of lands occupied by the tanneries at Hazaribagh of Dhaka city (BSCIC survey report, 2002) was clustered in 5 different blocks (B-1: Monessware Road Block, B-2: Sher-e Bangla Road Block, B-3: Mid Hazaribagh Block, B-4: Sonatagar/Gojmohal Block and B-5: Kalu Nagar Block) for collecting primary data by applying pre-tested unstructured and structured questionnaires.

The survey questionnaire was prepared to find out the number of tannery situated in Hazaribagh area as well as the maximum pieces of cow hide, buffalo hide, goat skin, and sheep skins processed by those tanneries in a day which was converted into weight as metric ton by applying the formula developed:

$$W = \frac{w \times n}{1000} \dots\dots\dots(1)$$

Here,

W = Weight of Hides/Skins (in MT)

w = Weight of Hides/Skins (in Kg/Piece) *

n = Number of Hides/Skins (in Piece)

***N.B.** The average weight of one-pieceraw cow hide, buffalo hide, goat/sheep skin are 12 Kg, 22 Kg and 1.5 Kg per piece respectively (UNIDO report, 2006).

Similarly, the amount of solid wastes generated was also quantified by using formula developed based on calculated raw weight of the hides and skins processed.

$$M = \frac{W \times p}{1000} \dots\dots\dots(2)$$

Here,

M = Weight of Solid Wastes generated (in MT)

W = Weight of Hides/Skins processed (in MT)

p = Weight of Solid Wastes generated (in Kg) **

****N.B.** 1000 Kg raw hides yields approximately 430 Kg Raw Trimmings, 250 Kg Shavings/Fleshings and 20 Kg Crust and Finished Leather Trimming. (Puntener, 1995).

Besides, the number of workers worked in those tanneries was also counted. The researcher used door to door method for collecting required information and made for direct observation, participant observation, and personal interview of related peoplesuch as executives, technologists, officers, workers, and experts to find out the impact of tannery solid wastes on people, economy and their socio-economic status.

III. Result and Discussion

3.1 Observed effects of tannery solid wastes on soil

The Hazaribagh Tannery area of Dhaka city is surrounded by the river Buriganga. The total land area occupied by the sector in here is 60 acres. Now a day, the area is protected from flood by the embankment which created some low land inside and outside of the area. This low land is used for dumping solid wastes of tannery. There is a by-pass road of Dhaka city linking Gabtoli to Sadarghat on the embankment. As the dumping ground is located by the roadside, the soil of this area is duly affected by the solid wastes. Simultaneously, the effluent is discharged through a canal and several drains to this low land and finally falls into the Buriganga River.

Table-1: The estimated average (Mean ± SD) values of chemical parameters of soil at Hazaribagh, Dhaka in the year 2011

Sl. No.	Name of the station	pH	Organic carbon (%)	Organic matter (%)	Total nitrogen (%)	Chloride (%)	Chromium (%)
S-1	Beribandh	7.86 ±0.225	7.97 ±0.170	13.70 ±0.292	1.54 ±0.137	0.247 ±0.0284	2.28 ±0.0291
S-2	Kalunagar	7.59 ±0.353	2.48 ±0.042	4.27 ±0.075	0.33 ±0.037	0.034 ±0.0022	0.17 ±0.0170
S-3	Company ghat	4.08 ±0.192	3.59 ±0.008	6.18 ±0.013	0.21 ±0.029	0.003 ±0.0003	0.02 ±0.0003
S-4	Rayer bazar	6.53 ±0.260	3.15 ±0.004	5.42 ±0.069	0.23 ±0.056	0.009 ±0.0004	0.35 ±0.0158
S-5	Gojmohol	6.56 ±0.164	3.15 ±0.164	5.42 ±0.284	0.35 ±0.041	0.012 ±0.0016	0.11 ±0.0151
	Standard for soil	7.00	1.85	3.1	1.35	0.05	0.08

It has also been found that not only the soil and water of Hazaribagh area are being polluted by tannery solid wastes and effluents but the air is also being polluted in different ways especially due to the production of smog emitted by the animal glue manufacturing factories.

3.2 Physical and chemical parameters of produced glue by traditional method

Animal glue was produced in the IES laboratory, Rajshahi following traditional methods and analyzed to compare physical and chemical properties of the glue samples with those of the sample glue collected from local market. The results are presented in the table-2.

Table-2: Physical and chemical parameters of glue produced in the laboratory following traditional methods

Sl. No.	Glue Sample	Physical parameters			Chemical parameters					
		Colour	Odour	Adhesive strength	pH	As h (%)	F at (%)	Chloride (%)	Moisture (%)	
1	G-1	Brown	Bald	Sufficient	7.5	30.86	3.30	37.44	30	
2	G-2	Brown	Bald	Sufficient	7.5	25.63	7.60	83.35	46	
3	G-3	Brown	Bald	Sufficient	7.5	63.53	7.90	81.98	31	
4	G-4	Brown	Bald	Sufficient	7.5	23.14	4.36	70.02	18	
5	G-5	Brown	Bald	Sufficient	8.0	18.71	0.90	6.72	17.77	
6	Standard	Yellowish	Nil	Sufficient	6.5	3.50	0.50	2.00	15	

All types of glue produced from the above process including showed the same physical properties but varied in chemical analysis which beyond the standard level of quality. Also the sample collected from the local market producing by traditional method of glue manufacturing process does not show the similar properties as described standard.

3.3 Environmental parameters of Effluent generated in glue manufacturing process

Effluent generated in producing animal glue in the IES laboratory, Rajshahi following traditional methods and analyzed to compare environmental parameters of the effluents generated from tannery and with those of Bangladesh standard. The results are shown in the table-3.

Table-3: Environmental parameters of Effluent generated in glue manufacturing process

Parameter	Steps	Effluents						Bangladesh standard**
		G-1	G-2	G-3	G-4	Tannery effluent*		
Color	Pre-Soaking	Earthly	Earthly	Earthly	Earthly	Earthy	Nil	
	Soaking	Yellowish	Yellowish	Yellowish	Yellowish	Yellowish		
	Liming	Green	Gray	Green	Gray	Gray		
	Washing	Clear	Clear	Clear	Clear	Clear		
Odor	Pre-Soaking	Septic	Septic	Septic	Septic	Septic	Nil	
	Soaking	Septic	Septic	Septic	Septic	Septic		
	Liming	Foul	Foul	Foul	Foul	Foul		
	Washing	Nil	Nil	Nil	Nil	Nil		
pH	Pre-Soaking	6.5	6.5	6.5	6.5	6.7	6-9	
	Soaking	8.5	8.5	8.5	8.5	8.7		
	Liming	13.0	11.0	13.0	11.0	13.2		
	Washing	11.0	11.0	11.0	11.0	11.0		
Total Suspended Solid (in ppm)	Pre-Soaking	2800	2320	2560	2237	2320	150	
	Soaking	14315	10000	12860	9870	12860		
	Liming	3730	3145	2700	2500	2700		
	Washing	1236	1142	1798	1500	1798		
Total	Pre-	26090	2016	2492	1812	24920	2100	

Dissolved Solid (in ppm)	Soaking		5	0	7	
	Soaking	35753	2831	3056	2038	30560
	Liming	30175	2200	2710	2320	27100
	Washing	2142	1528	1760	1240	1760

Source: Islam, R.M.S., 1998, Studies on the Degree of Pollution Resulting during the Production of Wet Blue Leather from Goatskin, *B. Sc. In Leather Technology Dissertation*, University of Dhaka, 60pp. Bangladesh Gazette, 1997.

3.4 Wastes utilized and glue produced

A total of 384Kg of solid wastes were used in bulk production of animal glue following modified methods producing 89.5Kg of glue in five slots. The data has been shown in the following table-4.

Table-4: The amount of solid wastes utilized in the animal glue manufacturing process following modified methods at Hazaribagh, Dhaka

Sample	Solid Wastes Used (Kg)				Glue produced (Kg)	Solid remaining/gaad (Kg)
	Raw Trimmings	Fleshings	Pickle cuttings	Total		
AG-1	50	6	6	62	13.5	19.5
AG-2	50	13	6	69	14.0	18.5
AG-3	50	20	6	76	19.0	21.0
AG-4	50	25	6	81	21.0	23.0
AG-5	50	40	6	96	22.0	30.0
Total	250	104	30	384	89.5	112

3.5 Physical and chemical parameters of produced glue by modified method

Animal glue was produced in bulk quantity following modified methods and analyzed to compare physical and chemical properties of the glue samples with those of the sample glue collected from local market. The results are presented in the table-5.

Table-5: Physical and chemical parameters of glue produced following modified methods at Hazaribagh, Dhaka

1. No.	Parameter	Standard	Market Sample	Sample AG-1	Sample AG-2	Sample AG-3	Sample AG-4	Sample AG-5
	Colour	Yellowish	Brown	Yellowish	Yellowish	Yellowish	Yellowish	Yellowish
	Odour	Nil	Bad	Nil	Nil	Nil	Nil	Nil
	Adhesive strength	Sufficient	Sufficient	Sufficient	Sufficient	Sufficient	Sufficient	Sufficient
	pH	6.5	8.0	8.5	8.0	8.0	8.0	8.5
	Moisture (%)	Max. 15	17.77	12.57	11.34	14.88	8.13	13.08
	Ash (%)	< 3.5	18.71	2.37	2.94	2.21	2.39	2.41
	Fat (%)	< 0.5	0.90	2.17	2.95	3.51	3.57	3.73
	Chloride (%)	< 2.0	6.72	1.41	1.67	1.17	1.35	1.28
	Nitrogen (%)	< 18	12.76	15.03	13.82	13.09	14.91	13.20
0	Protein (%)	-	80	93	86	82	93	83

3.6 Cost involved

A total of 50 Kg lime at the rate of Taka 10/- per kg lime and 1.75 Kg phenyl Taka 300/- per kg rate were purchased from the local market to process solid wastes for manufacturing animal glue from raw trimmings, fleshings and pickle cuttings following modified process. There were some access costs involved for collecting solid wastes which referred to as dumping cost in the cost sheet. There were 4 workers directly involved in producing the animal glue from using the tannery solid wastes. A lump sum amount of Taka was expended for using water and miscellaneous performance during animal glue production period following modified method. There was a significant amount of money expended for making the modified steel drum with chimney for controlling smog generation, which was not mentioned in the cost sheet as it was a fixed cost. This cost sheet includes the running production cost only which was calculated Taka 3193/-. The produced animal glue was sold to the local buyer at the rate of Taka 37/- per Kg. Thus A total Taka 3311.50 was the selling price of the produced glue and Taka 118.50 was the profit margin on the basis of production cost.

Table-6: Production costs of glue manufacturing following modified methods at Hazaribagh, Dhaka

Name	Materials Required		Total cost (BDT)
	Quantity (Kg)	Rate (BDT/Kg)	
Lime	50	10	500
Phenyle	1.75	300	525
Solid wastes (dumping cost)	384	2	768
Labourer	4	300	1200
Water & others	-	-	200
Production Cost			3193
Glue sold	89.5	37	3311.50
Profit margin			118.50

3.7 Environmental parameters of effluent generated in modified glue manufacturing process

Effluent generated in producing animal glue at Hazaribagh, Dhaka following modified methods and analyzed to compare environmental parameters of the effluents generated from tannery and with those of Bangladesh standard. The results are shown in the table-7.

Table-7: Environmental parameters of effluent generated in glue manufacturing process following modified methods at Hazaribagh, Dhaka

Parameters	Steps	Effluents					Tannery effluent*	Bangladesh standard**
		A G-1	A G-2	A G-3	A G-4	A G-5		
Color	Pre-Soaking	Ea rthy	Ea rthy	Ea rthy	Ea rthy	Ea rthy	Earthy	Nil
	Soaking	Gr ay	Gr ay	Gr ay	Gr ay	Gr ay	Yellowish	
	Liming	Wh ite	Wh ite	Wh ite	Wh ite	Wh ite	Gray	
	Washing	Cl ear	Cl ear	Cl ear	Cl ear	Cl ear	Clear	
Odor	Pre-Soaking	Se ptic	Se ptic	Se ptic	Se ptic	Se ptic	Septic	Nil
	Soaking	Se ptic	Se ptic	Se ptic	Se ptic	Se ptic	Septic	
	Liming	Fo ul	Fo ul	Fo ul	Fo ul	Fo ul	Foul	
	Washing	Ni l	Ni l	Ni l	Ni l	Ni l	Nil	
Ph	Pre-Soaking	6.5	6.5	6.5	6.5	6.7	6.7	6-9
	Soaking	8.3	8.3	8.3	8.3	8.7	8.7	
	Liming	11.0	11.0	11.5	11.5	13.2	13.2	
	Washing	11.0	11.0	11.0	11.0	11.0	11.0	
Total suspended solid (in ppm)	Pre-Soaking	2650	2300	2260	2237	2400	2320	150
	Soaking	10315	10700	11860	12070	12160	12860	
	Liming	3080	3120	3200	3276	3310	2700	
	Washing	1200	1247	1298	1365	1400	1798	
Total dissolved solid (in ppm)	Pre-Soaking	25100	25345	24920	25756	26132	24920	2100
	Soaking	30335	29150	30560	30385	30896	30560	
	Liming	28313	27000	28297	29200	28100	27100	
	Washing	2056	1978	1760	1840	1960	1760	

Source: Islam, R.M.S., 1998, Studies on the Degree of Pollution Resulting during the Production of Wet Blue Leather from Goatskin, B. Sc. In Leather Technology Dissertation, University of Dhaka, 60pp. Bangladesh Gazette, 1997.

IV. Conclusion

Naturally Bangladesh has abandoned supply of raw hides and skins, cheap labourers so that Leather industries of Bangladesh should be operated well with utilizing those available resources. But it was found in the tenure of this study that numbers of tanneries were being reduced gradually year after year due to unplanned industrialization, lack of knowledge of tannery people on environmental concerns and uncontrolled generation and dumping of wastes. It was also notified that huge amount of solid wastes was generated during processing of leather in tannery and spread the pollution over a large area of Dhaka due to uncontrolled dumping of it. It was also observed that in the present system of leather processing, solid wastes generation cannot be minimised for ensuring leather quality as well as there was no scope of set up new mechanism of scientific wastes management plant in Hazaribagh congested area to protect environment from tannery solid wastes pollution. So Government has taken initiative to relocate tannery from Hazaribagh to Savar, Dhaka with set up effluent treatment plan for effluent management and dumping ground for scientific dumping of solid wastes. But it should be considered that solid wastes are the part of valuable resources and required to utilize through process development and modification of by-product industry. And the by-product industry should be set up adjacent to the tanneries which minimising the transportation cost of wastes as well as the wastes would be utilized at the point of origin so that environment would be clean and eco-friendly.

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