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STUDIES ON RECYCLING OF EFFLUENT IN LATEX CREPE FACTORY

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In order to study the feasibility of recycling waste water in pale latex crepe (PLC) processing and its possible effects on the quality of the processed rubber, an experiment was conducted with fresh water, the waste water arising from the last three rollers (reusable water) and the raw effluent. The raw rubber properties of the processed rubber were compared with those of ISNR 3L. The PLC processed with raw effluent in all rollers recorded the lowest pH and the highest titrable acidity compared to that of PLC prepared with fresh and reusable water. Dirt content, ash content, volatile matter and nitrogen in the treatments with reusable water were comparable to the treatment with fresh water in all rollers. Initial plasticity and plasticity retention index of the PLC processed with reusable water were within the prescribed limits specified for ISNR 3L. PLC processed with reusable water could be graded as PLC 1X. The properties of sole crepe made from PLC prepared using reusable water were also within the prescribed limits. Fungal growth on PLC and sole crepe processed with reusable water was also comparable to that on the control. Waste water from the 3rd to 5th creping rollers could thus be reused in the 1st and 2nd creping rollers with 41.3 per cent savings in fresh water consumption and reduction in the quantity of effluent.

INTRODUCTION

There has been a growing awareness on the need to conserve the limited water resources. Reuse of treated waste water will definitely be more advantageous in situations where fresh water availability is very limited.

Pale latex crepe (PLC) and sole crepe are produced from fresh field latex. These rubbers require ninety to ninety five liters of water per kilogram during machining the coagulum to wash out the serum and other non-rubber materials (Kuriakose and Nair, 1980). Since the same coagulum is repeatedly washed through the various creping rollers, contamination of the water becomes less towards the end. Reuse of this water for the primary washings would lead to lesser use of fresh water as well as reduction in the quantity of waste water to be treated, thereby reducing the overall cost of processing (Middleton, 1977). An experiment was carried out to study the feasibility of recycling a part of the waste water in PLC processing and its effect on the quality of the processed rubber.

MATERIALS AND METHODS

Water used for the processing

The creping battery in the factory, where the experiment was carried out, consists of five rollers. The waste water arising from the last three rollers (reusable water) was collected separately while that from the first two rollers was allowed to flow into the effluent tank (Fig. 1).

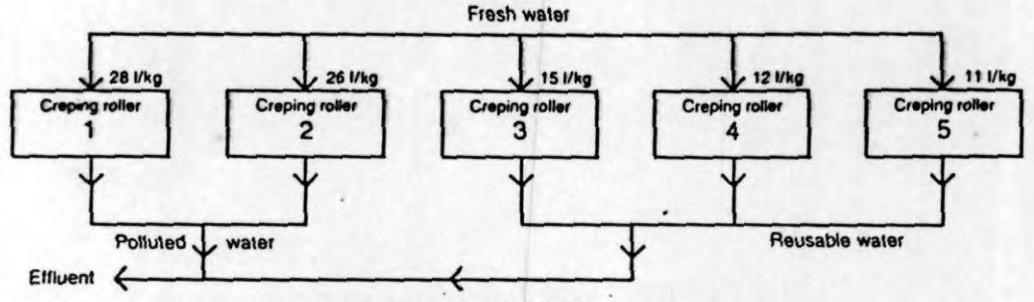

Fig. 1. Flow diagram of PLC processing

These water samples were analysed for the quality parameters *viz.*, (1) pH, (2) biochemical oxygen demand (BOD), (3) chemical oxygen demand (COD), (4) suspended solids, (5) dissolved solids, and (6) oil and grease, as per standard methods (APHA, 1975).

The reusable water was filtered through a filter designed specifically for this purpose. The filter consisted of gravel, sand and polyurethane foam. Fresh water, filtered waste water from the last three rollers and the raw effluent from the factory were used as per different treatments described below:

1. Fresh water in all rollers
2. Reusable water in the first three rollers and fresh water in the 4th and 5th rollers
3. Reusable water in the first four rollers and fresh water in the 5th roller
4. Reusable water in all rollers
5. Raw effluent in the first three rollers and fresh water in the 4th and 5th rollers
6. Raw effluent in the first four rollers and fresh water in the 5th roller
7. Raw effluent in all rollers

The waste water from the rollers using reusable water was also analysed for the various quality parameters.

Properties of rubber

The pH, percentage acidity and population of bacteria and yeast in the PLC samples processed as per the above treatments were studied. The processed PLC was kept for drying in a drying shed. The raw rubber properties of the PLC samples were determined as per the relevant BIS test methods (BIS, 1972). The parameters studied included pH, acidity, dirt content, ash content, volatile matter, nitrogen content, initial plasticity (Po), plasticity retention index (PRI), acetone extract, total bacteria, and yeast.

The PLC was graded visually. Sole crepe was made from the PLC processed as per the above treatments and was tested for the specification parameters prescribed for ISNR 3L. The PLC as well as the sole crepe were stored for 6 months and the monthly population of fungus in unit area of the solid rubber was also studied by plating the washings on Martin's rose bengal streptomycin agar medium.

RESULTS AND DISCUSSION

Characteristics of the water

The pH of the raw effluent was 5.1 and that of the reusable water 6 (Table 1). BOD and COD in the raw effluent were 1320 and 3180 mg/l respectively. However, in reusable water, these were only 160 and 310 mg/l respectively. Suspended solids in the raw effluent was 750 mg/l, while it was only 250 mg/l in the reusable water which got reduced considerably on filtration. Dissolved solids was also lower for reusable water. Oil and grease in raw effluent was 12 mg/l and in the reusable water it was only 6.5 mg/l which was completely eliminated on filtration.

Table 1. Waste water characters

Parameter	Raw effluent	Reusable water	Reusable water after primary treatment	Tolerance limit
pH	5.1	6.0	6.0	5.5-9
BOD	1320	160	150	50
COD	3180	310	285	250
S. solids	750	250	Trace	100
D. solids	2800	650	580	2100
Oil & grease	12	6.5	–	10

(Concentrations in mg/l except for pH)

Properties of PLC

The pH of the PLC processed with raw effluent in all rollers recorded the lowest level *i.e.*, 3.9 and titrable acidity recorded the highest value (Table 2). This trend was noticed in all the treatments with the raw effluent. PLC processed with reusable water in the first three rollers gave a pH value of 5.2 which was comparable to that of the PLC processed with fresh water *i.e.*, 5.4. The low pH in PLC was evidently due to the acidity of the raw effluent used for washing (Mathew *et al.*, 1986). The lower acidity and higher pH of PLC processed with raw effluent in the first three rollers could be due to the use of fresh water in the 4th and 5th rollers.

Table 2. Physical and microbiological properties of PLC with recycled water

Treatment	pH	Acidity in terms of formic acid (%)	Total bacteria (10^2/cm^2)	Yeast
Fresh water in all rollers	5.4	0.014	25	35
Reusable water in 1-3 rollers	5.2	0.015	32	42
Reusable water in 1-4 rollers	4.9	0.017	35	54
Reusable water in 1-5 rollers	4.6	0.015	46	46
Raw effluent in 1-3 rollers	4.4	0.015	49	52
Raw effluent in 1-4 rollers	4.0	0.016	53	60
Raw effluent in 1-5 rollers	3.9	0.018	200	112

The population of bacteria and yeast were 20×10^3 and 112 respectively in the PLC processed with raw effluent in all the rollers. Treatment with reusable water reduced the population of bacteria and yeast to levels comparable to the control (Table 2).

Raw rubber properties of PLC

Dirt content in the PLC with raw effluent in all rollers was 0.1 per cent while it was only 0.008 per cent in the treatment with fresh water alone (Table 3). Dirt content, ash content, volatile matter and nitrogen in the treatments with reusable water were comparable to that with fresh water in all rollers. However, in the case of samples prepared with raw effluent on all rollers, these values were marginally higher, indicating the level of contamination caused by treatment (Nair *et al.*, 1988).

Initial plasticity (Po) of PLC processed with raw effluent alone was 52 but it was 54 in the treatment with fresh water as well as with reusable water (Table 3). Plasticity retention index (PRI) was 75 in PLC prepared with raw effluent while it was 80 in the case of fresh water and 78 in the case of PLC with reusable water. PRI is a measure of the resistance to thermo-oxidative degradation, which is normally reduced by contamination with pro-oxidants (Mathew and Thomas, 1975; Sivabalasundaram and Nadarajah, 1966). Acetone extract was 3.6 per cent in PLC processed with raw effluent while it was 3.2 per cent in the case of PLC processed with fresh water and 3.3 per cent in the case with reusable water, further indicating the possible contamination by the use of raw effluent in all the rollers.

Usually PLC is graded visually by the colour of the product. The best grade is PLC 1X. As the brightness of the colour decreases, the material is downgraded as 1, 2, etc. (RMA, 1979). The grade was 2 in the case of PLC with raw effluent alone and it was 1X in the control as well as that with reusable water in the first four rollers (Table 3). The lower grade of the PLC with raw effluent is attributed to contaminants.

Table 3. Raw rubber properties of PLC with recycled water

Treatment	Dirt content (%)	Ash content (%)	Volatile matter (%)	Nitrogen (%)	Po	PRI	Acetone extract (%)	Grade
Fresh water in all rollers	0.008	0.230	0.500	0.35	54	80	3.2	1X
Reusable water in 1-3 rollers	0.007	0.230	0.520	0.35	54	78	3.3	1X
Reusable water in 1-4 rollers	0.007	0.240	0.530	0.34	54	78	3.3	1X
Reusable water in 1-5 rollers	0.008	0.243	0.548	0.33	53	77	3.4	1
Raw effluent in 1-3 rollers	0.008	0.243	0.535	0.34	53	76	3.4	1
Raw effluent in 1-4 rollers	0.007	0.255	0.552	0.33	52	76	3.3	2
Raw effluent in 1-5 rollers	0.100	0.267	0.568	0.35	52	75	3.6	2
Specification parameters for ISNR 3L	0.03 (Max)	0.50 (Max)	0.80 (Max)	0.60 (Max)	30 (Min)	60 (Min)	–	–

Raw rubber properties of sole crepe

The pH and acidity of the sole crepe prepared with raw effluent on all the rollers was 4.1 and 0.008 per cent respectively, while it was 5.7 and 0.005 per cent respectively in the treatment with reusable water in the first three rollers (Table 4). Volatile matter, ash content and nitrogen content were 0.66, 0.22 and 0.36 per cent respectively in sole crepe with raw effluent in all the rollers. At the same time these were 0.60, 0.20 and 0.33 per cent respectively in the control. In the treatment with reusable water these values are close to those obtained in control (Table 4).

Dirt content was 0.008 per cent in the sole crepe with raw effluent alone while it was 0.005 per cent in the control. This was 0.006 per cent in the sole crepe processed with reusable water which is comparable with the control and also within the limit prescribed for ISNR 3L (Table 4).

Table 4. Raw rubber properties of sole crepe with recycled water

Treatment	pH	Acidity in terms of formic acid (%)	Nitrogen (%)	Volatile matter (%)	Ash content (%)	Dirt content (%)	Po	PRI	Acetone extract (%)
Fresh water in all rollers	5.7	0.005	-327	0.60	0.20	0.005	53	80	3.2
Reusable water in 1-3 rollers	5.6	0.005	0.327	0.60	0.21	0.006	52	79	3.2
Reusable water in 1-4 rollers	5.2	0.005	0.333	0.67	0.22	0.004	51	78	3.2
Reusable water in 1-5 rollers	4.9	0.005	0.340	0.67	0.22	0.004	51	78	3.4
Raw effluent in 1-3 rollers	4.6	0.006	0.340	0.65	0.21	0.006	52	76	3.4
Raw effluent in 1-4 rollers	4.3	0.007	0.340	0.66	0.22	0.004	50	75	3.5
Raw effluent in 1-5 rollers	4.1	0.008	0.360	0.66	0.22	0.008	50	75	3.5
Specification parameters for ISNR 3L	–	–	0.60 (Max)	0.80 (Max)	0.50 (Max)	0.03 (Max)	30 (Min)	60 (Min)	–

Initial plasticity (Po) for the sole crepe processed with raw effluent alone was less (50) compared to that of the control (53). Po of the sole crepe processed with reusable water was comparable with that of the control. Plasticity retention index was also less for the treatment with raw effluent (75). But it was comparable in the case of the treatment with reusable water (78-79). Acetone extract was also high (3.5%) in the treatment with raw effluent while with reusable water it was comparable to the control.

Effluent characteristics after recycling

Properties of effluent after using the reusable water and fresh water in PLC production are given in Table 5. There was a decrease in pollution parameters according to the extent of use of fresh water. Even though reusable water was used in the beginning, since it was subsequently washed with sufficient quantity of fresh water, the impurities in the processed rubber was reduced. This was evident from the increase in pollution parameters, wherever reusable water was used. The pollution parameters of effluent collected from the 3rd to the 5th roller with fresh water and 1st and 2nd rollers with reusable water, were comparable with that of effluent from the treatment with fresh water on the rollers.

Fungal population

The result of the studies on fungal population on the PLC and sole crepe are given in Tables 6 and 7. Both the rubber samples processed with raw effluent showed maximum fungal population (4×10^3 and 30×10^3) after six months, while it was only 16×10^2 and 12×10^2 in the control. Rubber samples processed with reusable water in the first three rollers showed a fungal population of 18×10^2 and 14×10^2 respectively, which is comparable with the control. Effluents are generally loaded with biodegradable organic compounds and hence rubbers treated with the effluent are prone to attack by mould on storage (Kuriakose and Sebastian, 1980).

Table 5. Effluent characters after recycling with reusable water

Source of waste water	pH	Dissolved solids mg/l	Suspended solids mg/l	Oil and grease mg/l	BOD mg/l	COD mg/l	Total bacteria per ml
1+2 rollers of fresh water	5.5	825	628	6	1394	3575	45×10^4
3+5 roller after fresh water	6.3	120	75	5	120	320	40×10^2
1+2 roller after reusable water	5.4	950	655	7	1415	3820	32×10^5
3-5 roller after fresh water	6.2	125	80	5.5	152	370	48×10^2
Third roller after reusable water	6.1	122	82	2	168	325	55×10^3
4-5 roller after fresh water	6.2	110	75	2.5	94	252	42×10^2
3+4 roller after reusable water	6.0	115	70	3	185	366	65×10^3
Fifth roller after fresh wash	6.3	85	55	2.5	165	260	18×10^2
3-5 roller after reusable water	6.2	145	80	6	188	462	85×10^3

Table 6. Fungal population on PLC with recycled water (10^2 cm^{-2})

Treatment	Months					
	1	2	3	4	5	6
Fresh water in all rollers	6	8	10	13	15	16
Reusable water in 1-3 rollers	8	10	11	13	16	18
Reusable water in 1-4 rollers	12	14	15	18	21	23
Reusable water in all rollers	15	18	20	22	24	25
Raw effluent in1-3 rollers	10	14	17	19	21	22
Raw effluent in 1-4 rollers	12	20	23	26	27	30
Raw effluent in all rollers	160	210	240	280	340	410

Table 7. Fungal population on the sole crepe with recycled water (10^2 cm^{-2})

Treatment	Months					
	1	2	3	4	5	6
Fresh water in all rollers	2	4	5	7	9	12
Reusable water in 1-3 rollers	4	7	9	11	13	14
Reusable water in 1-4 rollers	5	8	12	15	17	18
Reusable water in all rollers	10	10	13	16	18	20
Raw effluent in1-3 rollers	8	11	13	15	16	17
Raw effluent in 1-4 rollers	8	10	12	16	17	19
Raw effluent in all rollers	160	200	240	260	280	300

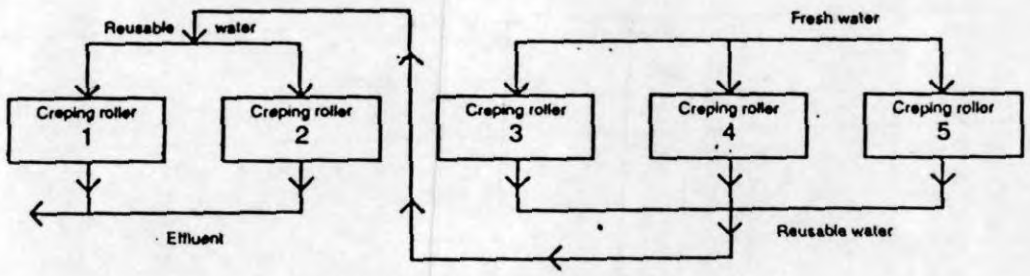

Fig. 2. Flow diagram of water recycling in PLC

CONCLUSION

In PLC processing waste water from the 3rd to the 5th rollers could be reused in the 1st and 2nd rollers after filtration (Fig. 2). The raw rubber properties of PLC and sole crepe processed with reusable water are meeting the specification parameters of ISNR 3L. A saving of 41.3 per cent in terms of fresh water consumption could be achieved.

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