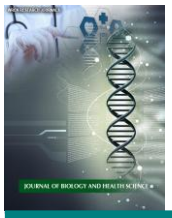

Journal of Biology and Health Science

ISSN: 3108-0189

Research Article

WRJBHS-24-004

Enhancing Productivity of Latex Lifting Operation of Rubber Plantation Using Industrial Engineering Techniques

Uche Emmanuel Uche* and Ibrahim Momoh-Bello Omiogbemi

Department of Mechanical Engineering, Air Force Institute of Technology, Kaduna, Nigeria

***Correspondence:** Uche Emmanuel Uche, Department of Mechanical Engineering, Air Force Institute of Technology, Kaduna, Nigeria, E-mail: eaumie@gmail.com; DOI: https://doi.org/10.56147/jbhs.1.1.4

Citation: Uche EU, Omiogbemi IMB (2024) Enhancing Productivity of Latex Lifting Operation of Rubber Plantation Using Industrial Engineering Techniques. J Biol & Heal Sci 1: 4.

Abstract

In the competitive commodity market, where raising the selling price of natural rubber in the face of increasing cost of production is becoming increasingly difficult due to stiff competition by its alternative synthetic rubber, rubber plantations must focus on productivity of operations. One key operational area for productivity improvement is the transportation of produce from fields to processing centres. An industrial engineering technique is deployed in this study to enhance productivity of latex lifting in a rubber plantation. The study includes analyzing the current method, proposing a new method and conducting a cost-benefit analysis. The findings indicate that adopting latex pit storage and pumping system could reduce operation time by 2.91 hours (29%) and save 4.47 hours in latex collection time. Additionally, the method eliminates 38% underutilization of tanker/tractor capacity (3980 litres *vs.* 6400 litres). However, the proposed method would increase ammoniation to 0.02% of latex weight and requires the use of 23 collection pits with capacities ranging from 1500 litres to 6000 litres. The cost analysis shows that the new method would save approximately ₦12,666,500 annually for the plantation, with a payback period of two years.

Key words: Productivity; Latex; Pit; Ammoniation; Cost benefit

Received date: September 06, 2024; **Accepted date:** September 24, 2024; **Published date:** October 08, 2024

Introduction

Productivity is generally considered to be the ratio of output to input. It generally expresses the relationship between the quantity of goods and services produced (output) and the quantity of labor, capital, land, energy and other resources to produce it (input). When measured, productivity is often viewed as a relationship between output and a single measure of input, such as labor or capital [1]. For this study, productivity is evaluated by how effective the labor and machines are, by measuring performance, utilization and method levels. Productivity improvement measures can therefore be applied using any of the four industrial engineering techniques: (1) redesign of operations, (2) automation and mechanization, (3) use of mass production and (4) application of new technology [2]. To achieve productivity improvements in farm operations including transportation of produce, the most practical approach is to examine the work process itself, that is, to review and redesign the operations followed by mechanization of the process. In this study, a productivity audit, employing Industrial Engineering (IE) techniques is used for evaluating the existing latex collection processes and identifying the potential for increased productivity. The improvement process therefore began with an audit of the current productivity situation in the aspects of operations, workers, equipment and tools using work study methods a group of techniques that ensures improved productivity. Work-study is made up of two phases, namely:

- Method study
- Work measurement.

Method study objective is to establish optimum method of doing the work while the work measurement objective is to establish the time required for an adequately trained and qualified worker to do the job at defined level of

Journal of Biology and Health Science

ISSN: 3108-0189

performance. The overall objective is to make the best possible use of human and material resources in carrying out any specific activities [3]. The purpose of the study is therefore to achieve an increase in productivity of the operators as well as in tractor allocative efficiency by introducing field storage of latex in field pits and pumping of the stored latex into tractor mounted tanks. In doing this the study will consider the entire value stream, from field latex collection to factory reception to facilitate improvements that will enhance the flow of value to the company. The aim is to reduce operator's inactivity period on latex collection and to enhance tractor allocative efficiency in the case study rubber plantation.

Materials and Methods

The work-study method adopted will yield a measure of operator and tractor performance, utilization and coverage. It assumes that the methods are reasonably good and that all the resulting production is needed by the company. In a profit-oriented environment as the one understudy, the approach is expanded to include a cost analysis.

Materials

Product characterization

Tapped latex consist of a suspension of rubber particles (30%-40%) in liquid serum of water (59%-62%) and other particles (3%-5%), shows white to yellow coloration, viscid and relative density less than one hence floats on water [4]. Spontaneous coagulation is initiated on exposure to dirt due to bacteria activity in the production of Volatile Fatty Acid (VFA). Here ammonia is added to inhibit bacteria growth and delay coagulation The percentage of ammonia and its concentration determine time to start coagulation. To be considered here are therefore the two basic challenges that exist when pumping latex:

- Latex emulsions are extremely shear-sensitive, requiring pumps that reliably deliver a low shear rate product.
- Any contact with air will further polymerize the latex, making it imperative that the pump feature a seal-less design. Furthermore, pumps with mechanical seals usually require flushing, which can create possible leak path or dilution of the latex solution.

Machine

Tankers pulled by tractors are used to transport latex from the reception to the factory. Tractors are checked daily for oil, water, fuel electrical, mechanical *etc.* While the tankers require tyres, bearing, cleaning, welding *etc.* Their status and usage are as shown in **table 4**.

Tools and consumables

Tools that accompany the tractor/tanker include sieve to filter the latex, sponge, knives, bucket *etc.* Ammonia is poured into the tanker (5lts of 5% Ammonia 25% to 3000 litres of latex) before pouring latex to reduce bacteria activities which causes early coagulation an activity usually accelerated by dirty latex and dirty tanker.

Methods

The study adopts the work-study empirical and experimental approach with the tapping blocks, tapping fields and the rubber processing factory constituting the study areas. It therefore starts with work simplification, involving preliminary study, analysis of the present method, criticizing the present method and elaboration of the new method and ends with the cost benefit analysis. The cost benefit analysis is based on the time of each element of work done Time Per Unit (TPU) using stopwatch to obtain an estimate of man-machine-hour required per unit output. Finally, the occupation of the worker the percent of time the worker is normally occupied during the work cycle is established.

Preliminary study of latex lifting: Problem definition

A clear definition of the problem provides the basis for measurement, analysis and improvement.

Study area

Post: Tractor latex collection

Workplace: Rubber plantation.

- Workshop: Tractor check and parking.
- Factory: Crop reception and tanker wash/park.
- Field latex collection, water supply and addition of preservative ammoniation **(Figure 1)**.

Figure 1: Study area.

Journal of Biology and Health Science

ISSN: 3108-0189

Personnel information

Tractor operators, mates and headmen.

Divisional managers, supervisors, headmen, factory crop receptionist and laboratory supervisor.

Latex collection

The quantity and frequency of latex collection is a function of the tapping system, age of trees, stimulation practices, season, clone, number of tapped trees *etc.* Tapping usually starts by 6 am and finishes about 11 am for crop lifting (crops to bucket) to commence about 12 pm, permitting latex reception and transport to the factory at about 1 pm **(Figures 2 and 3)**.

Figure 2: Latex collection.

Figure 3: Manual latex tank filling.

Safety Consideration

Rain boots, raincoats and latex sheds.

Quality consideration

Ammoniation as soon as possible after tapping, clean field and tanker condition as well as clean latex and early discharge into bulking tank at the factory. Tankers are kept clean by scouring and washing with water immediately after use.

Post before field latex collection/reception

Post after factory reception is bulking.

Storage facilities, supply and evacuation

Latex is stored in cups, drums and tankers while waiting for collection by tapers and lifting with the tractors. Ammonia is supplied by the laboratory and brought to the field by tractors/tankers that come from the workshop/factory.

Ergonomics

Tractors and bicycles are used to collect latex to ease crop reception and reduce drudgery.

Production

Over four million litres of latex is expected to be transported from the field to the factory for the year table 6.

Similar post

Collection of latex in pits at the reception centers and pumping into tractor mounted latex tankers.

Problem definition

The purpose of the study will be to achieve an increase in productivity of the operators as well as in tractor allocative efficiency. Tractor latex collection is to be retained.

Interest of the study

To reduce tractor hours by 50%.

To reduce latex collection shift hours by 75%.

Opportunity of the study

During the peak production months of October/ November and rainy month of August.

Limit of the study

From muster to factory reception of crop.

Aim of the study

To introduce field storage of latex and pumping of latex into tractor mounted latex collection tanks thereby reducing operator's inactivity period and enhancing tractor use efficiency.

Journal of Biology and Health Science

ISSN: 3108-0189

Means

Personnel and latex collection machine/equipment.

Bill book

Preliminary study-June

Shift study-August

Analysis/criticism-August

Elaboration/orientation-September

Stabilization/implementation-October

Time study-November

Follow up- December-April

Pay and control-May.

Conclusion

Do we do the study? Yes.

What study do we do? To optimize the use of operators and tractor in lifting latex from the field to the factory.

Results and Discussion

Personnel information

Crop lifting or collection is by tenured staff members and contract loaders who are paid monthly. The team is made up of 6 operators and 2 mates with average age of 40 years and 14-year work experience as shown in **Table 1**: Their grades and training are also noted because work measurement objective is to establish the time required for an adequately trained and qualified worker to do the job at defined level of performance [5].

Table 1: Personnel information.

Name	Duty	Age	Experience	Grade	Training
Friday Ituen	Headman	44	22	1 Step 15	Preventive maintenance
Felix Omenogor	Operator	53	27	1 Step 9	Preventive maintenance
Monday Ejekaduwe	Operator	48	22	2 Step 6	Preventive maintenance
Sunday Omego	Operator	36	12	2 Step 6	Preventive maintenance
Emmanuel Benedict	Operator	36	6	4 Step 7	Preventive maintenance
Sunday Ogor	Operator	29	8	4 Step 12	Preventive maintenance
Sunday Aselue	Mate	35	10	3 Step 1	
Ifeanyi Animani	Mate	35	8	4 Step10	
Total	8	40	14		

Product characteristics

Latex processing (blocking) results in premium rubber product of 5M grade that attracts high market price. Laboratory result of latex preservation test using Ammonia 25% is shown in **Table 2**: Coagulation delay in the field pits is important to facilitate pumping of latex from the pits into the tractor mounted latex tanks and the subsequent discharge in the factory. The time to commencement of coagulation is a function of concentration of the ammonia, its quantity to a litre of latex and the latex dry rubber content (Drc.). 5% ammonia 25% to latex, that gives 4 hrs to commencement of coagulation is recommended **(Table 2)**.

Table 2: Latex preservation test result.

Date	Latex source	Drc %	Conc. %	% of ammonia 25% to latex	Before start of Coagulation (hr.)
24-06-2024	Expt.	34	10	2.5	3.83
24-06-2024	".	34	20	5	3.88
26-06-2024	"	29	7.5	1.88	2.1
26-06-2024	"	29	15	3.75	2.17
28-06-2024	Bulking tank	40	20	5	2.22
28-06-2024	"	40	10	2.5	1.93
28-06-2024	"	40	5	1.25	1.72
28-06-2024	"	40	12.5	3.13	2.15
28-06-2024	"	40	17.5	4.38	2.4
29-06-2024	"	36	20	5	3.2
29-06-2024	"	36	17.5	4.38	3.2

Remark: 1ml diluted ammonia 25% to 1 litre of latex.

Latex collection

Table 3 shows the estimated latex pit capacity per tapping parts in both A and B divisions made up of old and

Journal of Biology and Health Science

ISSN: 3108-0189

young areas in tapping for the months of June and November that represent wet and dry month productions. There are 22 field latex pits with capacity ranging from 1500 to 7000 liters per pit.

Table 3: Latex volume by reception center.

Div	Center	Part	No. of task	June daily latex (10.5% of annual production	Estimated Nov. daily latex (12.2% of annual Production)	Possible pit capacity (lt.)	Area
A	10	D	24	3200	3718	4000	Young mature
	24	C	24	3220	3741	5000	Young mature
	36	B	8	960	1115	1500	Young mature
	39	E	7	1120	1307	1500	Young mature
	41	C	8	1680	1952	2500	Young mature
	135	B	24	3200	3718	4500	Young mature
	119	B/C/D	12-12-2012	1260	1464	1500	Old area
	130	A	24	1280	1487	1500	Old area
	138	C	21	1320	1534	1500	Old area
	141	A/B	22	2120	2463	2500	intensive
B	57	A	13	3693	4291	5000	Young mature
	58	B/D	4	1100	1278	1500	Young mature
	69	A/B	13	2425	2818	3500	Young mature
	75	C	15	2547	2959	3500	Young mature
	105	D	8	1327	1542	2000	Young mature
	49	A/C	13	6080	7064	7000	Old area
	108	B/C	26/37	4764	5535	6000	Old area
	110	D	17	2460	2858	3000	Old area
	111	B	12	3672	4267	5000	Old area
	120	B	22	1940	2254	2500	Old area
	128	B	13	1274	1480	1500	Old area
	122	B	17	1704	1980	2000	Old area
	22						

Machine status and operation

Their ages and usage are as in **Table 4**: Only two out of the five tractors are of good operating age while three are into the wear out life phase. The distance from the field to the factory are depicted in Table 5.to indicate a range of 13 to 20 km. hauling 8000-17000 litres of latex per day with maximum trip time of 84 minutes. Tractors, able to pull 6400lts of latex per run (64 hp-70 hp) would be required.

Table 4: Equipment status.

Equipment	No	Capacity (Hp)	Age	Recommended load (tons)
Tractors	265-1	60	16	3
"	265-2	60	15	3
"	375-2	64	11	5
"	3.75E+00	64	5	6
"	Styr. 8075	64	3	6
Latex tanker	1	3180		
:	2	3200		
"	10	3000		
"	11	3400		
"	3	3200		
"	4	2720		
"	5	3080		
"	6	3200		
"	7	2200		
"	8	2000		
"	12	3680		

Journal of Biology and Health Science

ISSN: 3108-0189

Table 5: Distance and trekking time (12 km/hr).

Div	Part	Reception centers (field)	Possible latex load /day	Total distance (km)	Travel time (hr.)	Distance field to factory	Time (min)
A	A	130,137 141,41	8500	15	1.25	12.4	62
	B	141,135 119,36	10000	16.4	1.37	13.8	69
	C	138,119 24,41	10500	15	1.28	12.8	64
	D	40,119 10	8000	13.2	1.1	9.2	46
	E	39	1500				
B	A	49,57,69	15500	15.2	1.27	10.2	51
	B	58,69 108,122,120	15500	20	1.67	16.8	84
	C	49,75, 108	16500	19.2	1.6	14.2	71
	D	58,105,110, 111,128	-	-	-	-	-

Monthly latex production

Number and capacity of latex storage pits are determined by the production of latex during tapping. Table 6 depicts the production budget and the actual to date. The expected daily field latex production is 14,587 litres on the average from all the tapping parts.

Table 6: Latex production.

Month	Budget latex	Actual latex	Workdays	Latex/day	DRC
January	290297	215859	26	11165	0.4
February	176604	199254	22	8027	0.39
March	138858	167244	26	5341	0.38
April	302878	207430	26	11649	0.39
May	429155	363790	26	16506	0.36
June	454320	408876	26	17474	0.35
July	454320	418495	26	17474	0.32
August	454320	-	26	17474	-
September	454320	-	26	17474	-
October	479484	-	26	18442	-
November	530264	-	26	20395	-
December	328045		26	12617	
Total	4492865		308	14587	

Purpose and usefulness of the job

Post: Collection of latex with tractor.

What: Lifting latex from the field to the factory with tractor.

Why: For processing into crumb rubber, 5M

Benefit: To sustain and make profit for the company through sales.

Purpose: Latex is lifted with tractor to the factory from the field for processing into 5M crumb rubber, which is sold to sustain and to make profit for the company **(Table 7)**.

Table 7: Usefulness of the work activities.

Activity	Usefulness	Assignment of work	Action
Muster	Useful	Deficient in timing	To consider 10 am. for muster
Tank Inspection by laboratory supervisor	Useful	Deficient in timing and tools	Study to introduce right time, grading and monitoring tools.
Check tractor for oil, fuel water *etc.*	Useful	Deficient in timing	Study to establish best time for routine tractor daily check/fueling.
Couple/decouple tankers	Useful	Deficient	To suppress/modify the activity.
Fill tanker with water	Useful	Optimum	Continue study, establish objective
Break	Useful	Deficient in timing	Study to establish appropriate time and duration.
Latex Transport	Useful	Deficient in low tanker load and runs	To establish latex collection method and tank capacity to optimize transport.
Tank distribution	Useful	Deficient	To suppress activity

Journal of Biology and Health Science

ISSN: 3108-0189

Waiting for latex	Useful	Deficient	To suppress activity
Factory latex measurement	Useful	Optimum	Establish objective
Waiting to pull off tank after discharge/washing by mate	Partially useful	Deficient	Study to establish who does washing
Packing Tractor	Useful	Optimum	Establish objective

Analysis of the present method of latex collection

Tractor latex collection shift study summary

Date: 7/6/2024- Div: B

Post: Tractor latex collection- Part: B

Organizer: Uche E. Uche- Block: 108,127

Beginning of shift: 5.30 am- Clone GT I, R600 *etc.*

End of shift: 3.32 pm- Year of planting: Old

Duration of shift: 60200cmn=10.03hrs- Worker: Monday Ejekaduwe

Experience- 22 years

Result of Latex collection shift study **(Table 8)**.

- Total time of activities: 21199.6 cmn=35.22%
- Total time of inactivity: 3900.4 cmn=64.78%.

Table 8: Latex collection activity summary.

Activities	Cmn	Min	Start	End	Remark
Muster	2531.6	25.32	5.3	5.55	
Tank inspection by laboratory supervisor	1258.8	12.58	5.55	6.08	
Daily tractor checks for fuel, oil, electrical *etc.*	3504.7	35.05	6.08	6.43	Further delay due to fueling by other vehicles and to make report for repair
Tractor repair by welder	8904.1	89.04	6.43	8.12	
Pump water into tanker	586.4	5.86	8.12	8.18	
Break	13634.9	136.35	8.37	10.5	Parking/coupling 19 min
Traveling Time	10997.6	109.98			9.39 km/hr. two trips of 1580 and 2400lts
Set tank/add Ammonia/Discharge water into reservoir *etc.* in block 108/127	2875	28.75			
Coupling/decoupling of Tankers	2357.9	23.58			
Factory latex measure	391.9	3.92			Two tankers (3982) lts.
Waiting at field reception center for latex	10304.8	103.05	11.52	1.32	
Waiting at factory reception for mate to complete tanker washing before parking	2651.9	26.52			
Parking tractor at W/S	200.4	2		3.32	
Total	60200	602		3.32pm	

Stabilization (necessary for time study)

Hypothesis 1: To install reception pits at field reception centers, from where latex is pumped after reception into tractor pulled latex tank for transport to the factory.

The following activities/in-activities would be eliminated/reduced:

- Coupling/decoupling of tankers- 2357.9cmn (3.92%)
- Waiting for tappers to pour in latex (operator inactivity) 10304.8 cmn-(17.12%)
- Double runs to and from factory- 4793.3 cmn (7,96%)=17456 cmn (29%)=2.91 hrs
- Tanker/tractor underutilization: 3980 lts<6400 lts tanker/tractor capacity (38%).

Orientation

1. Muster: Latex tractor operators to muster by 10am for tractor fueling/checking. Saving includes.

- Break times (13634.9-6000) cmn-7634.9 cmn

Journal of Biology and Health Science

ISSN: 3108-0189

- Fueling/check time (no cars *etc.*)-1752.35 cmn 9387.25 cmn=1.56 hrs.

More light for thorough tank inspection by laboratory.

2. Waiting to remove tanker after washing (inactivity).

Younger operators to maintain a tanker and a tractor by cleaning (operators' inactivity) 2651.9 cmn (4.4%).

Conclusion

Possible saving in latex collection time is 4.47 hrs. These work hours can go into tractor lump collection from 10 am to 2 pm before latex collection using the same tractor and operator. All collected lumps should however be out before 2 pm.

Tractor lump collection shift study

Date 10/6/2024- Div: B

Post: Tractor lump collection- Part: B

Organizer: Uche E. Uche- Block 58,57,69,108,120,127

Beginning of shift: 11am- Operator: Friday Jonah

End of SS: 3.44pm- Duration of SS 25774.3 cmn=4.30 hrs **(Table 9)**.

Table 9: Result of tractor lump collection shift study.

Activities: 11457.3cmn-44.45%
Traveling time: 10830.8cmn
To flush/park tractor
In-activity 14317cmn=55.55%
Cleaning of Trailer 366.7cmn
Waiting /Washing/Loading of lump 9281.9cmn
Dressing up by mate 204.7cmn
Offloading (2286kg)
Rest by mate

Stabilization

Re-deploy operator during offloading to save 4463.7 (0.74 hrs) to reduce inactivity by 31%.

Orientation

- Tapers to bring out all collected lump before going for latex collection to facilitate weighing and tractor lifting before 2 pm.
- To have attached to each latex tanker a bin to collect few lumps received after lump lifting by tractor.
- To consider tipping trailer for lump haulage: To re-deploy mate instead of being engaged in offloading (1.60 cmn/kg).

Conclusion

Tractor lump collection and tractor latex collection can be compressed into 7 hrs normal presence time for a tractor operator using same tractor.

Material flow analysis

Work definition: Latex collection

Unit: A Tank of latex lifted

Limit: From latex field reception center to the factory.

Production/accessories: Latex, water, ammonia 25%.

Description: Water is discharged into field reservoirs and ammonia poured into the latex tanker by the operator. Tapers collect latex from the latex cups and brought it to latex shed to be measured by the Headman. The tapper poured the measured latex into the latex tanker for transport to the factory by the tractor. A repeat trip may be necessary **(Figure 4, 5 and 6)**.

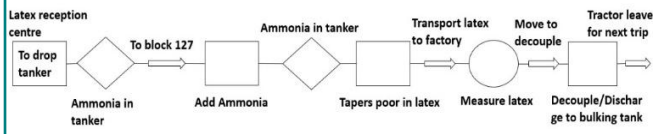

Figure 4: Material flow diagram.

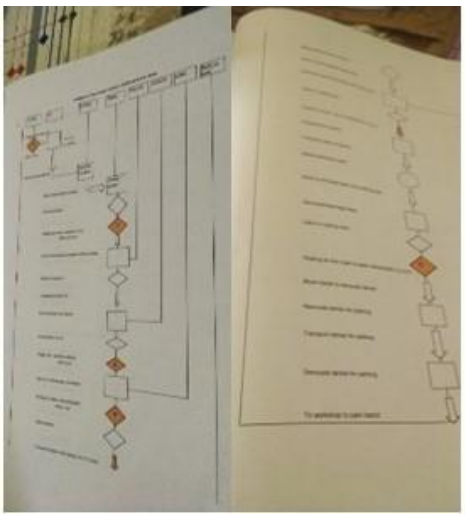

Figure 5: Outline process chart.

Journal of Biology and Health Science

ISSN: 3108-0189

Table 10: Tractor latex collection operation analysis.

ID	Task name	Duration	Start	Finish
1	Muster	25 cm	5.30 am	5.55 am
2	Tank Inspection	13 cm	5.55 am	6.80 am
3	Tractor check/repair	124 em	6.08 am	8.12 am
4	Coupling tanker/pump water into tanker/collect Ammonia	6 em	8.12 am	8.18 am
5	Coupling 2nd tanker/parking	10em	8.18 am	8.37 am
6	Break	136em	8.39 am	10.56 am
7	Drop 1st tanker in block 108	26em	10.55 am	11.21 am
8	Decoupled/discharge water/add ammonia to tanker (5lts)	19em	11.21 am	11.40 am
9	Drop 2nd tanker in block 127	11 am	11.40 am	11.51 am
10	Set tanker/add ammonia	3 am	11.51 am	11.54 am
11	Waiting for latex/tank filling	103 em	11.54 am	1.37 pm
12	Transport latex to factory (1580lts)	23 em	1.37 pm	2.00 pm
13	Measure latex/settling/decoupling for discharge	3 em	2.00 pm	2.08 pm
14	Travel back-to-back 108 for latex	25 em	2.03 pm	2.28 pm
15	Couple tanker/cover tanker	4 em	2.28 pm	2.32 pm
16	Transport latex to factory(2400lts)	25 em	2.32 pm	2.57 pm
17	Measure/decoupled/recouple to pull out after washing	10 em	2.57 pm	3.07 pm
18	Waiting for tanker washing by mates	27 em	3.07 pm	3.34 pm
19	Decoupling/parking tractor at workshop	3 em	3.34 pm	3.37 pm

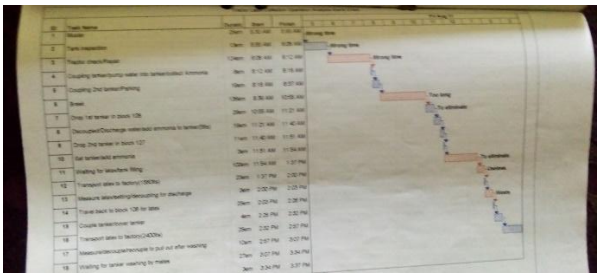

Figure 6: Tractor latex collection operation analysis Gantt-chart.

Work measurement

This involves timing the work and establishing the time per unit-T.P.U. **(Table 11)**.

Criticism and development of the new method

The result of productivity analysis is a clear picture of improvement opportunities. Operation's job design specifies the tasks, method and relationships of jobs to satisfy technological and organisational requirements as well as the social and personal requirement of the job holder [6].

Operations

Table 12 shows the proposed latex lifting operation schedule with the deployment of the latex pits and latex pumping system **(Figures 7 and 8)**.

Equipment and tools

Figure 7: Tractor mounted latex tank with PTO driven latex pump.

Figure 8: Tractor PTO latex pump.

Journal of Biology and Health Science
ISSN: 3108-0189

Table 11: Time study.

S/N	Tractor latex collection 1 tank of latex transported			Expt.	Uche E. Uche	09-06-2024	Sheet 1
	Description (Work elements)	Freq.	Time	Breakpoint	Remark	Critiques	Solutions
1	Muster	1	2531.6	Hand touch tank	-	Lift latex by noon	Muster by 10am
2	Tank inspection	1	1238.8	Hand touch tractor	-	Too early to see inside	Inspect by 10am
3	Check tractor/repair/couple tank	1	12408.8	Hand touch tap	Once a while	Wrong time	Check by 10.am
4	Pump water into tank/collection	1	586.4	Hand touch tractor	-	Ok	-
5	Coupling 2nd tank/parking	1	1900	Hand	-	Ok	-
6	Break	1	13634.9	Hand touch tractor	-	Too long/	Muster by 10am after breakfast
7	Transport tank to 108	1	2611.2	Hand touch tractor	-	Double movement	Install permanent pit and collect later
8	Discharge water/put Ammonia	1	1883.6	Hand touch tractor	-	Useful	Put ammonia into pit
9	Transport tank to 127	1	1140.1	Hand touch tractor	-	Suppress	Install pit and pump into tanker
10	Add ammonia/set tank	1	300	-	-	Useful	Put ammonia into pit
11	Waiting to collect latex	1	10304.8	Hand touch tractor	-	Useful	Install pit and lift by 2 pm
12	Transport latex to factory (1580(lts)	1	2315.1	Leg touch ground	-	Underutilization of tank	Use same tanker to collect center
13	Measure Decoupling	1	295.1	Hand touch tractor	-	Necessary	
14	Travel back to 108 for latex	1	2478.2	Leg touch ground	-	Useless only 3980lts	Use tank capacity of 6000lts
15	Couple/cover tank	1	440	Hand touch tractor	-	Too many coupling	Pump latex instead of coupling
16	Transport latex to factory (2400lts)	1	2453	Leg touch ground	-	Useless	Should be combined with the 1st
17	Measure/decouple/ Recouple	1	206.5	Hand touch tractor	-	Partially useful	Redesign Reception area to avoid decoupling
18	Waiting for washing	1	2651.9	Hand touch tractor	-	Useless	Young operator to wash
19	Parking at workshop	1	2.22	Hand touch tractor	-	Useful	Park with coupled tanker

Table 12: The new latex lifting operation schedule.

Activities	Action	Result	Interest
Muster	Modify	5.30 am to 10 am	To allow enough time for lump and latex collection 10 am to 5 pm=7 hrs (after breakfast)
Latex tanker inspection	Modify	5.55 am to 10.15 am	Enough daylight to see the inside of tank, grade cleanliness for bonus and take record for further action.
Tractor daily check	Modify	6.08 am to 10.30 am	No car to delay collection of fuel, oil *etc.*
Water/ammonia	Modify	8.12 am to 10.45 am	Fill tank with water and move to the filed-less pressure on tyres.
Parking	Eliminate	Couple trailer for lump (10.55)	Same tractor and operator for latex and lump
Break	Eliminate	To leave w/s for lump collection (11.00)	Saved one tractor and one operator
To drop tank	Eliminate	Lump collection (11.30	Saved tractor run of 2611.2 cmn

Journal of Biology and Health Science

ISSN: 3108-0189

Waiting for Latex	Eliminate	Lump transport (12.33)	Saved latex waiting time=10305 cmn/lump 2286 kg
Transport latex to factory	Modify	Decouple trailer at factory for mate to discharge (1.48)	Saved useless run of 4793.3 cmn for 1.580 lts of latex
Travel back for latex	Modify	Couple tanker (pump collect water and leave for latex collection (1.58)	Total latex to collect=3980lts Tanker capacity= 6400lts Pumping time=3980.240=17mn Preserve latex with ammonia in the ratio of 0.02% to latex weight *i.e.,* 10 lts to 3000 lts of 5% ammonia 25%. (5 lts to one tanker is the current practice).
Couple tank	Eliminate	Pump latex into water from pit in block 127 (2.21)	
Transport 2400 lts to factory	Modify	Travel to pump latex in block 108 (1580lts) (2.42)	Pumping 2400 lts=7 min
Measure/decouple	Modify	Transport 3980lts of latex to factory (2.49)	
Waiting for washing	Eliminate	Measure latex and discharge (3,14)	
Parking	Modify	Younger operators to wash tank/park/trailer (3.44)	Official closing is 5 pm

Table: 13: Use of equipment and tools for crop lifting.

Operation	Equipment	Action	Result	Interest
Lump collection	2 No.	Combine	Used for latex	Increase utilization of tractor
Latex transport	5 No. tractors	Eliminate	Use 3 No. tractor	Save 4 No. tractors
Latex collection	11 No. tankers	Reduce	Transport with 6 No 3200 lts tankers	Saving 5 No. tankers and accessories (bearing, tyres *etc.*)

Workers

Table 14: Posts.

Operation	Staff	Action	Result	Interest
Latex collection	Operator	Combine	To wash tank and collect lump	Inactivity Eliminated
Lump collection	Operator	Combine	To collect latex and wash tank	Reduce inactivity to 38.2%
Latex collection	Mates	Eliminate	Operators to wash tankers	Cost reduction on 2 No mates.

Elaboration of the new method

The result of productivity analysis is a clear picture of improvement opportunities. The new method is to temporary store latex in field pits and use pump to fill the tanker while increasing ammoniation to 0.02% of latex weight depending on weather, field hygiene level and Drc.

Twenty-three collection pits of variable capacity are proposed (see preliminary studies) ranging from 1500lts to 6000lts. The total capacity is 70,500lts (70,5m3). Aluminum pits or concrete work with light aluminum surface cover is suggested. Portable pit for flexibility of location is also considered because of the ongoing planting program. Flexible system using plastic drums is shown in **figure 9**.

Figure 9: Flexible field latex storage.

Journal of Biology and Health Science
ISSN: 3108-0189

To wash the pits, elevated sloppy shallow pit with water reservoir and tap at the top and drain at the lower end is proposed involving scurrying and washing with water (or bactericide) immediately after use. Washing to be done by tapper on overtime as an incentive for good tapping work. Epoxy or coating material may be used to facilitate cleaning and prevent uptake of iron by the latex that may discolor the latex. Latex tanker to supply water into water reservoirs before pumping latex. The new method and the benefits are elucidated in the **Table 15**.

Table 15: The benefits of the new method.

Operation	Action	Result	Implication
Latex collection	Modify	1. Store latex in pit 2. Use pump to fill tanker 3. Increase ammonization to 0.02% of latex weight depending on weather, field hygiene level and Drc 4. 3 tractors for latex and lump.	1. Installation of aluminum pits 23No 2. Installation of tanker pump 3 No 3. Reduction of tractors:4 No tractors 4. Reduction of operators: 4 No 5. Reduction of tankers 5 No. 6. Elimination of mates 2 No. 7. Pit cleaning overtime for tapper: 1.5 hrs
Lump collection	Combine	Collect all lump before 2pm continue with latex collection.	Reduction of in-activities.

Three tractors, able to pull 6400lts of latex per run (64 hp-70 hp) would be required. Time of presence for lump and latex collection is seven hours made up of lump 3 hours and latex 4 hours. Details by tapping parts are as shown in the Table. The best tanker capacity is 2 No 3200 lts ($3.2m^3$) tankers per tractor. The modify latex lifting system will achieve 10.8 km with 3,980 lts of latex in 1.15 hrs **(Table 16)**.

Table 16: Operation details per tapping part.

Div	Part	Estimated latex (peak) in litres	Distance (km)	Tractor hours	Latex pumping hours	Operating hours	Tractors	Tankers
A	A	8500	15	1.6	0.56	2.19	1	2
	B	10000	16.4	1.74	0.69	2.44	1	2
	C	10500	1.5	1.6	0.73	2.33	1	2
	D	8000	13.2	1.41	0.59	1.97	1	2
B	A	15500	15.2	1.62	1.08	2.7	2	4
	B	15500	20	2.13	1.08	3.21	2	4
	C	16500	19.2	2.04	1.15	3.19	2	4
	D	13000	14	1.49	0.9	2.39	2	4
Design (total/4)	8	27000	36.4	3.88	1.88	5.75	3	6

To preserve the latex in the pit till collection is necessary to have clean field condition and for the cleaned pits and latex to be protected from weather. Furthermore, ammonia should be added as soon as possible after taping in one good dose (to avoid resistance by bacteria producing VFA). Ammoniation should be constantly monitor and adjust according to perceived Drc and weather (presently 0.01% to latex weight). A rule of the thumb is that 3% ammonia to latex weight will preserve the latex till 6 pm. Finally, it is of utmost importance to lift to the factory as quickly as is possible. Axiomatically the factory can receive the production without extra cost.

What is the gain? The economic gains are shown in **Table 17** and summarized as follows:

Investment- N 374,198,500

Eliminated expense- N198,695,300 per year

Extra reduction- N 12,666,500 per year

Staff reduction- 6 No

Payback period- 2 years **(Table 18)**.

Cost benefit analysis

Table 17: Cost analysis.

Resource	Present	Proposed	Gain	Loss	#/yr x 100	Remark
Tractor (repair/fuel/oil charges)	7 No	3 No	4 No		10,67,801	
Tractor hours/day (operating cost)	45 hrs	21 hrs	24 hrs		17,93,919	N249/hr. (without depreciation charge)
Tankers	11 No	6 No	5 No		179.8	
Operators	7 No	3 No	4		3,53,584	

Journal of Biology and Health Science

ISSN: 3108-0189

Mates	4 No	2 No	2		1,07,321	
Operators' inactivity	62%	17%	45%		2,78,447	45% of wage
Pump	Nil	3 No	Nil	3 No	10,50,000	Market
Pits	Nil	23 No	Nil	70.5 m^3	26,91,985	(N31000 per aluminum sheet (8ft by 4 ft by 6mm)
Ammonia	0.01%	0.02%	Nil	0.01 m^3	1,16,280	5% of Ammonia 25% (N1900/jar)
Overtime on pit washing	Nil	1.5 hrs	nil	1.5 hr.	10,385	N4706/month basic.

Table 18: Recommendations for further study.

Operations	Studies
Latex collection	Eliminate by use of ploy bags collection installed on the trees
Lump collection	Eliminate mate by use of tipping lump table and tipping trailers
Latex collection	Ammonia concentration to latex Drc. and weather.
Latex collection	Use of plastic pits for latex reception-cheaper
Latex collection	Use of truck for latex haulage.

Recommendations and Conclusion

The present latex lifting operation design was studied, analyzed, criticized and alternative method elaborated. Finally, the latex lifting system was subjected to cost analysis which is the objective re-engineering. All the research questions raised in the preliminary study were answered. The new method is to temporary store latex in field pits and use pump to fill the tractor mounted tanks with increase in ammoniation to 0.02% of latex weight depending on weather, field hygiene level and Drc. Twenty-three collection pits of variable capacity are proposed (see preliminary studies) ranging from 1500lts to 6000lts. The cost saving is N 12,666,500 per year with staff reduction of two and payback period of two years. The following areas of the rubber crop lifting operations **(Table 18)** are recommended for further studies.

References

1. Smith KE (2004) The concept and importance of productivity. The McGraw-Hill Companies: Tokyo, Japan.
2. Shoichi S (2004) Case study: Reducing labor costs using industrial engineering techniques. The McGraw-Hill Companies: Tokyo, Japan.
3. Uche EU (2021) Optimization of individual rubber tapping labour supply using work-study method. IOSR Journal of Mechanical and Civil Engineering 18: 40-54.
4. Webster CC, Baulkwill WJ (1989) Rubber. Longman Group UK Limited.
5. Banga TR, Sharma SC (2019) Industrial organization and engineering economics. Khanna Publishers: New Delhi, India.
6. Davis LE (1966) The design of job. New York Press.