STUDY AND OPERATION OF EFFLUENT TREATMENT PLANT: ROSIN AND TURPENTINE OIL INDUSTRY BILASPUR (HIMACHAL PARDESH): A CASE STUDY

Submitted in partial fulfillment of the requirement for the award of the degree of

Master in Technology

In

ENVIRONMENTAL SCIENCES AND TECHNOLOGY

Submitted By

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CERTIFICATE

I hereby certify that the work which is being presented in thesis entitled, **"Study and Operation of Effluent Treatment Plant: Rosin and Turpentine Oil industry BILASPUR (HIMACHAL PARDESH): A Case Study",** in partial fulfillment of the requirements for the award of degree of master of technology in environmental sciences, Thapar University, Patiala, is an authentic record of my own work carried out under the supervision of **Mr. Anoop Verma.** Lecturer, DBTES and **Mr. Pankaj Anand** (Environmental Engg. & Owner of Indian Climate Control Company).

The matter presented in this thesis has not been submitted for the award of any other degree of this or any other university.

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This is certified that the above statement made by the candidate is correct and true to the best of my knowledge.

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(Ashok Kumar Tanwar)

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ABSTRACT

Any process in industry that uses fresh water will generate waste water or effluent with different contaminants. Over the past two decades the environment regulatory requirements has become stringent because of increased awareness of human health and ecological risk associated with the environment contaminants. One of the main causes for these contaminants is the industrial discharge from textiles industry, paper and pulp industry, rosin and turpentine oil industry, and many other chemical and pharmaceuticals industries, thus posing a threat to living beings.

During M. Tech. thesis, I got the opportunity to work in Rosin and Turpentine oil industry. The concerned industry is located in Bilaspur (Himachal Pradesh). In that region, there are only two such industries. The project is concerned with the successful installation and operation of the ETP of the said industry. In the industry, rosin mix with soil and some turpentine oil are the main contaminants. In the project, complete study of the industry was done regarding all the point sources from where the waste and the effluent can be generated. To fulfill the above task, I understood all the processes with their inputs and outputs, and then ETP was installed, operated and maintained successfully. The ETP was operated and maintained as per the required conditions of the industry. Time to time analysis of the effluent has been done by measuring COD, BOD, pH, TDS etc. The ETP was maintained with repeated experimentation till the parameters under control as per pollution control board. Some new technologies are applied for solving the problems occurred at the time of successful operation of ETP.

CHAPTER 1 INTRODUCTION

Man's well being depends upon the environment in which he lives. In his effort to improve the quality of life, man has been constantly interacting with his environment, the extent of interaction changing over space and time. Population growth and the intensification of human activities through agricultural development, urbanization and industrialization have created many environmental problems.

The amount of water existing on earth (oceans, lakes, rivers, polar regions, glaciers, underground water, water of the biosphere and atmosphere) is around 1.4 x 10^9 km^3 from where only ~0.8 –1.0%(i.e., ~1.3 x 10^7 km^3) corresponds to total drinking water. World water consumption per year is about 9 x 10^3 km^3 and at present, the quantity of available potential drinking water per year is between 10 and 30 x 10^3 km^3. This numbers clearly illustrates how even a small shortage of water could become a threat to mankind. Besides, the world suffers from growing health and hygienic problems and a high percentage of diseases in developing countries are caused by a deficient water supply.

1.1 THE IMPORTANCE OF WATER

With two thirds of the earth's surface covered by water and the human body consisting of 75 percent of it, it is evidently clear that water is one of the prime elements responsible for life on earth. Water circulates through the land just as it does through the human body, transporting, dissolving, replenishing nutrients and organic matter, while carrying away waste material. Further in the body, it regulates the activities of fluids, tissues, cells, lymph, blood and glandular secretions.An average adult body contains 42 litres of water and with just a small loss of 2.7 litres he or she can suffer from dehydration, displaying symptoms of irritability, fatigue, nervousness, dizziness, weakness, headaches and consequently reach a state of pathology.

1.2 THE HISTORY OF WATER

Water has been used since antiquity as a symbol by which to express devotion and purity. Some cultures, like the ancient Greeks, went as far as to worship gods who were thought to live in and command the waters. Whole cities have been built by considering the location and availability of pure drinking water. The place of gathering was around the wells, which is perhaps the following trend in building fountains in the middle of piazzas.

Traditional and modern medicine have been makings use of the psychological and physiological diverse properties of water, in all forms of hydrotherapy (composite Greek word: hydro, of water and therapy, We all know of the simple, yet effective, calming qualities of a warm bath or the invigorating qualities of a cold shower). For centuries, numerous healing springs located all around the world have been recognized for their benefits. The famous Belgium spas in the Ardennes is a fine example. Historical records of these cold springs claim 'cures' since the fourteenth century. The hot Californian spas, the healing spas of Loutraki in Greece, the Dalhousie hot springs in the border of South Australia and Northern Territory, Moree in NSW, Hepburn mineral spas in Victoria are just a few examples

1.3 OUR WATER TODAY

Contrary to the past, our recent developed technological society has become indifferent to this miracle of life. Our natural heritage (rivers, seas and oceans) has been exploited, mistreated and contaminated.

The population decline of the marine and riparian life, the appearance of green algae in the rivers and the stench and slime that comes as a result of putrefaction in the water, are clear signs of the depth and extent of disruption that has been caused to this intricate ecosystem. Government bodies and water authorities will have us believe that it is 'safe' and we should not worry about this global alarm. Awareness and action lies entirely upon us, as we need to become our own educators, physicians and innovators. Water also regulates the temperature of the planet and cycles essential nutrients through the land, air, and all living things. The flow of water through the atmosphere, biosphere, lithosphere, and hydrosphere is called the hydrologic, or water, cycle. Thus, water is both the most abundant natural resource on our planet and a fundamental element of life whose preciousness requires diligent management.

Many argue that privatization, rather than state-control, produces the most equitable, environmentally friendly, and economically sound system for managing both the distribution and consumption of water. Water rights which are transferable from one individual to another are the fundamental building blocks of such a system. Rather than government controlling access to water, in a private system individuals buy, sell, and trade water rights, just as we do with property rights today. However, critics charge that private water markets will undersupply consumers and lead to unequal distribution, skewing towards those with more means. Yet, in practice, this seems not to be the case.

Interestingly enough, privatization benefits are actually most visible in developing countries. People living on the margins, without recognizable property or water rights, are able to access clean drinking water for a small cost because local water vendors have responded to the many failures of government supply. In West Africa , for example, small, disposable bags of clean drinking water called "sachets" are available throughout the region for only a few cents. Many foreign companies are also responding to this increased demand, shipping large amounts of bottled water to consumers who need it most.

In creating a realistic market for water, price increases will effectively treat water as a finite and precious resource, reflecting all costs associated with its use; therefore, individuals will adapt, innovate, and find creative ways to trade and conserve. When prices do not reflect scarcity, it can result in waste, inefficiency, and environmental degradation.

1.4 THE TRUTH ABOUT THE DRINKING WATER

Our drinking water today, far from being pure, contains some two hundred deadly commercial chemicals. Add to that bacteria, viruses, inorganic minerals (making the water hard) and you have a chemical cocktail that is unsuitable (if not deadly) for human consumption. John Archer in his book 'THE WATER YOU DRINK, HOW SAFE IS IT?' refers to an estimate of 60,000 tonnes of fifty different chemicals being deliberately added annually to Australia's water. Some of these are:

CHLORINE: studies1 indicate that chlorine is involved in heart disease, hardening of the arteries (arteriosclerosis), anaemia, high blood pressure, allergies and cancers2 of the bladder, stomach, liver and rectum. Further, chlorine can destroy protein in the body and cause adverse effects on the skin and hair. The US COUNCIL of environmental quality states that cancer risk among people drinking chlorinated water is 93% higher than among those whose water does not contain chlorine".

ALUNIMIUM SULFATE: that is added to clarify water, has long been associated with memory loss, possibly Alzheimers disease and is believed to increase cardiovascular disease.

SODIUM FLUORIDE: this is not a water treatment and was initially added as a supplement to 'assumingly' prevent tooth decay in children. Its toxicity is high enough that in larger concentrations can be used as a pesticide and rat killer. In humans it can be damaging to the heart, lungs, liver, cause genetic mutations and have long term negative effects on enzyme production and the efficiency of the immune system.

INORGANIC MINERALS: (minerals not suitable for human consumption) such as calcium carbonate, have their effect. Unable to be assimilated they store in between joints, muscles, bones, nerves, inside arteries and become partners in many crippling dis-eases, such as arthritis, hardening of the arteries, gall stones, kidney stones, gout, tinnitus and perhaps even stroke and neuralgia.

NITRATES: Nitrates from fertilizers when brought in contact with chlorine and ammonia, can turn into nitrites. Nitrites once inside the body combine with amines and form nitrosamines which are highly carcinogenic. Nitrites can interfere with oxygen uptake and since babies are specifically sensitive to this aspect you could not fail to see a possible link between blue baby syndrome and the nitrite factors

1.5 USE OF WATER IN INDUSTRY

Water is the main component which is used in all type of the Industries. Water is used for different processes in the industries. It may be used for washing, dilution, formation and condensing the steam. But all water used in the different industry is not totally consumed. Generally, almost all the industries generate waste water that needs urgent attention.

Water use in industry is a double-edged sword. On one hand it puts immense pressure on local water resources. On the other, wastewater discharged from the industry pollutes the local environment. Water is required, often in large volumes, by industries as process inputs in most industries. In other cases, like food and beverage and chloro-alkali industry, water is used as a raw material: turned into a manufactured product and exported out of the local water system.

However, in most industries it is essentially used as input and mass and heat transfer media. In these industries a very small fraction of water is actually consumed and lost. Most of the water is actually meant for non-consumptive process uses and is ultimately discharged as effluent.

1.6 QUANTITY AND QUALITY

The amount of water available matters but so also does its quality. Industry requires water of good quality for its use, and for this it uses cleaner upstream water. However, the water it discharges is always of lower quality than the feed water and this wastewater is discharged downstream. At best the wastewater discharged represents a quality that can be recycled for lower grade of industrial use and at worst represents water quality which is unsuitable for every use other than navigational purposes.

Table 1. Water use in different Indian industries

Industrial Sector	Annual wastewater water discharge (million cubic meters) (%)	Annual consumption (million cubic meters)	Proportion of water consumed in industry
Thermal power plants	27000.9	35157.4	87.87
Engineering	1551.3	2019.9	5.05
Pulp and paper	695.7	905.8	2.26
Textiles	637.3	829.8	2.07
Steel	396.8	516.6	1.29
Sugar	149.7	194.9	0.49
Fertilizers	56.4	73.5	0.18
Others	241.3	314.2	0.78
Total	30729.2	40012.0	100.0
Source: Estimated by CSE based on the wastewater discharged data published by CPCB in "Water quality in India (Status and trends) 1990 - 2001".			

1.7 MAJOR CONSUMERS

Water consumption depends on the type of industry. Whereas thermal power, textiles, pulp and paper and iron and steel are highly water intensive sectors, industrial sectors like chloro-alkali, cement, copper and zinc and plastics require little water.
Data on actual water consumption in India is absent. However, the data on wastewater discharge by various industrial sectors in the country is available. The data on wastewater discharge has been complied by CPCB. According to CPCB, the total wastewater discharged by all major industrial sources is 83,048 million liters per day (mld). This includes 66,700 mld of cooling water discharged by thermal power plants (TPPs). Out of the remaining 16,348 mld of wastewater, TPPs generates another 7,275 mld as boiler blow down water and overflow from ash pond.

According to CPCB the annual water consumption in Indian industry is 40 billion cubic meters and the annual wastewater discharge is about 30.7 billion cubic meters. Therefore, the overall ratio of wastewater discharged to freshwater consumption in Indian industry works out to be about 0.77. That is, for every cubic meter of water consumed by Indian industry, 0.77 cubic meters of wastewater is discharged. Considering this, CSE (center of science and environment) has estimated the possible water consumption in various industrial sectors in India.

Thermal Power Plants (TPPs): Most TPPs in India are owned by the government. Indian TPPs are one of the highest consumers of water as compared to their global counterparts. On an average, for every 1000 Kwh power, Indian TPPs consume as much as 80 cubic meters of water. The water consumption in the modern TPPs in developed countries is less than 10 cubic meters for every 1000 Kwh. The major reason for this atrocious figure is the widespread prevalence of 'once-through cooling systems'.

Pulp and paper: Water consumption in Indian pulp and paper industry is significantly higher than in developed countries: Complete discharge of paper machine wastewater, which can be recycled easily.Use of chlorine-based bleaching technology in wood and non-wood based mills. Due to the presence of chlorine compounds in the bleach wastewater, it cannot be used as 'black liquor' for energy generation and hence is discharged.

Textiles: The textile industry in India guzzles double the accepted amount for consumption. Why is this so? A major factor is obsolete technology which permits minimum recycling and reuse of process water. For instance, most textile mills in India do not use counter-current washing systems; instead they use clean water at every stage of the wash cycle. Similarly the reuse of final rinse water from dyeing for dye bath make-up or reuse of soapier wastewater, is absent in most mills.

Iron & Steel: The Iron & Steel sector is also water intensive industry. In India, approximately 80-85 per cent freshwater consumed in this sector is discharged as effluent. In contrast, in USA over 95 per cent of the water used for steel production and processing is recycled. Consequently, while the Indian steel companies consume about 10-80 cubic meters water to produce a single tonne of steel, in the US only 5-10 cubic meters of water is needed. Global best practice for wastewater discharge in integrated iron and steel plant is less than 0.1 cubic meter per tonne steel.

Indian industry will have to reduce its voracious appetite for water. Water, the once inexhaustible natural resource, is going to be one of the most important factors to decide the growth and development of Indian industry in the future

Table 2. Average water consumption in Indian industry

Sector	Average water consumption in Indian industry	Globally best
Thermal power plant	On an average 80 m^3/ mwh(1)	Less than 10 m3/mwh(2)
Textiles	200-250 m3/ tonne cotton cloth(3)	Less than 100 m3/ tonne cotton cloth(2)
Pulp & Paper	• Wood based mills: 150 - 200 m3 / tonne(3) • Waste paper based mills: 75 - 100 m3/ tonne(3)	• Wood based mills: 50 - 75 m3 / tonne(4) • Waste paper based mills: 10-25 m3/tonne(4)
Integrated Iron & steel plant	10-80 m3 per tonne of finished product (average	5 -10 m3 per tonne of finished product. Best is around 25 m3)(practice - less than 0.1 m3 wastewater per tonne finished product(5)
Distilleries	75-200 m3/ tonne alcohol produced(6)	Data not available
Fertiliser industry	• Nitrogenous fertiliser plant - 5.0 - 20.0 m3/ tonne(3) • Straight phosphatic plant - 1.4 - 2.0 m3/ tonne(3) • Complex fertiliser - 0.2 - 5.4 m3/ tonne(3)	An effluent discharge of less than 1.5 m3/ tonne product as P2O5(2)

Table 2. Estimates done by CSE from wastewater discharge data from "Water Quality in India, Status and trends (1990-2001), CPCB, MoEF" and annual electricity generation data from "Annual

Report (2001-2002) on the working of state electricity boards and electricity department, Planning Commission." 2. Pollution prevention and abatement handbook, World Bank. 3. Environmental management in selected industrial sectors - status and need, CPCB & MoEF, February, 2003. 4. Green Rating of Pulp and Paper Sector, CSE. 5. Integrated Pollution Prevention and Control (IPPC), Best available techniques reference document on the production of iron. 6. Environmental performance of Alcohol industry in UP, UPPCB, 2000-2001.

The waste water contains different types of solid materials, chemicals, oil, grease, some organics and inorganic waste. It is not possible to drain the water in the rivers, land, or other surface water sources. So there is need to treat the wastewater before draining it. There are many processes which are used treat the waste water. There are physical, chemical and biological processes for the treatment of the waste water depending upon the properties of the waste water.

CHAPTER 2 LITERATURE REVIEW

2.1 QUALITY CRITERIA, SPECIFACTIONS AND TEST METHODS

2.1.1 Rosin

Although several other criteria determine rosin quality and acceptability for different applications, color and softening point are usually sufficient indicators of quality to satisfy purchasers of rosin from traditional and proven sources. Rosin is graded on the basis of color, the palest being the most desirable and designated WW* ('water-white'). This grade and the slightly lower grade WG ('window-glass') are the most commonly traded rosins. A superior grade, X, is sometimes offered. Darker grades are N, M, K, I, H and lower. Rosin is a glass, rather than a crystalline solid, and the point at which is softens when heated is referred to as the softening point (rather than melting point). A softening point in the range 70-80°C is usual, the higher end of the range representing the better quality.

* The notation follows the USDA (United State Deptt. of Agriculture) color scale for rosin which is used universally in international trade.

Since rosin is an acidic material and the manufacturer of downstream derivatives depends on its acid functionality, a high acid number (and saponification number) is also an indication of good quality. The better quality rosins usually have an acid number in the range 160-170. Provided that the acid number is high, the detailed resin acid composition of rosin is usually of little consequence or interest to the end user. An exception is rosin derived from *P. merkusii* which, because of the presence of a rather rare resin acid, has an acid number which is higher than normal; it may reach 190 or more. The percentage of unsaponifiable matter indicates the amount of non-acidic material in the rosin, so the lower this value, the better; anything above about 10% unsaponifiable matter would be considered a poorer quality rosin.

There are no international standards for rosin, and although the American Society for Testing and Materials (ASTM) describes standard test methods, it stipulates no specifications to which rosin should conform. The appropriate controlling bodies of some producing countries do provide specifications but, inevitably, companies and traders involved in the rosin industry have their own 'in-house' specifications which will vary from company to company, and this makes it difficult to generalize and quote 'typical' analytical data.

Table 3, which was compiled from trade sources, presents some specifications for gum rosin of different origins and may be used as a guide for assessing the acceptability of rosin by those thinking of entering rosin production.

Data such as the contents of volatile oil, insoluble matter, ash and iron (which should all be low) may be specified by producers of rosin. Other, less well defined properties, such as the tendency of the rosin to crystallize (which is undesirable), also affect its value; Chinese and, to some extent, Indonesian rosin have this particular shortcoming.

Table 3. Some trade specifications for gum rosin

Origin	Color	Softening point (°C)	Acid number	Saponification number	Unsaponifiable matter (%)
China, PR	WW	70-85	162-175		max 7.5
Portugal	WW	min 70	165-171	171-177	4.3-5.5
Brazil	X/WW	70-78	155-170	165-185	max 10
Indonesia	WW/WG	75-78	160-200	170-210	

For determination of these physical data, reference should be made to the definitions and methods of analysis given by the ASTM. The following test methods concerning rosin are described (*Annual Book of ASTM standards*, Section 6):

D 269-92	Insoluble matter in rosin
D 464-92	Saponification number of rosin
D 465-92	Acid number of rosin
D 509-70	Sampling and grading rosin
D 889-58	Volatile oil in rosin
D 1063-51	Ash in rosin
D 1064-58	Iron in rosin
D 1065-92	Unsaponifiable matter in rosin

D 3008-90	Resin acids in rosin by gas-liquid chromatography
E 28-92	Softening point by ring-and-ball apparatus

2.1.2 Turpentine

Specifications for 'gum spirit of turpentine' have been published by several national bodies including the American Society for Testing and Materials (ASTM D 13-92) and the Bureau of Indian Standards (IS 533:1973). These standards were devised largely for the quality assessment of turpentine intended for use as a solvent, i.e., in whole form rather than as a chemical feedstock in which the composition is of prime importance. They generally specify parameters such as relative density or specific gravity, refractive index, distillation and evaporation residues.

The International Organization for Standardization (ISO), which is a world-wide federation of national standards institutes, has issued a standard, the main requirements of which are shown in

Table 4.

A draft ISO standard for 'Oil of turpentine, Portugal type, *Pinus pinaster* (1994) includes physical data very similar to that in Table 4 but with the addition of a range for optical rotation (20°C) of -28° to -35°. Compositional ranges are also given for a number of constituents of the turpentine including alpha-pinene (72-85%) and beta-pinene (12-20%).

Table 4. Physical property requirements of the International Organization for Standardization specification for gum spirit of turpentine (ISO 412-1976)

Relative density (20/20°C)	Refractive index (20°C, D line)	Distillation (% v/v)	Evaporation residue (% m/m)	Residue after polymerization (% v/v)	Acid value	Flash point (°C)
0.862-0.872	1.465-1.478	max 1 below 150°C min 87 below 170°C	max 2.5	max 12	max 1	min 32

Turpentine purchased by the chemical industry as a source of isolates for subsequent conversion to pine oil, fragrance and flavor compounds, and other derivatives, is assessed on the basis of its detailed composition. The major demand is for turpentines containing high total pinene content. *P. elliottii* turpentine contains around 60% of alpha-pinene and 30% of beta-pinene. *P. radiata* turpentine, noted earlier as being of exceptionally good quality, generally contains more than 95% of total pinene, of which over half is beta-pinene; it has virtually no high-boiling constituents. However, the relative proportions of other components may also influence an individual buyer's quality evaluations; 3-carene, which is found in significant proportions in the turpentine of some *Pinus* species (such as *P. roxburghii* and *P. sylvestris*) is of little value, and even if it is present in relatively small amounts it may be undesirable for certain applications. Depending on the variety, *P. caribaea* turpentine may contain up to 50% or more of beta- While such a composition does not diminish its value as a solvent for paints, it would not be attractive as a source of pinenes for derivative manufacture.

Genetic factors influencing resin composition and yields

Some of the factors which affect resin yields have been referred to earlier. Genetic factors play a major role in determining both yields and composition (quality) of the resin, and a provisional judgement on the suitability of a standing resource of pines for tapping can often be made simply by consideration of the species concerned. For example *P. patula*, which is widely planted in Africa, gives a very poor quality resin in low yields, and is not tapped commercially anywhere in the world. *P. caribaea* provides turpentine and rosin of acceptable, but not exceptional quality, but it is now being recognized as a particularly high-yielding species; in Africa and Brazil it has out-yielded *P. elliottii*, a species often used as the benchmark by which others are judged. *P. radiata*, on the other hand, produces probably the best quality turpentine in the world, but resin yields are poorer than *P. elliottii*, for example, and it is not widely tapered. Table 5 gives an indication of the relative quality and quantities of resin which might be expected from some species of *Pinus*.

Table 5. Resin quality and yield characteristics of some *Pinus* species

Species	Quality	Quantity
P. elliottii	++	++
P. pinaster	++	+
P. massoniana	+	+
P. merkusii	+	+
P. caribaea	+	+++
P. radiata	+++	+
P. roxburghii	+	+
P. kesiya	+	+/-
P. oocarpa	+/-	+/-

Note: Resin characteristics are rated on a scale from very good (+++) to poor (-)

The list is not intended to be exhaustive, and no attempt has been made to provide specific quantity values based on yield data reported in the scientific literature. Such data encompass a wide range of variables (age and size of trees, climate, tapping method, etc.) and it could be misleading to quote precise figures. Site-specific factors can affect the rating either favourably or adversely, so a relatively poor rating does not mean that the species cannot be used (*P. oocarpa* and *P. sylvestris* are tapped in Mexico/Central America and Russia, respectively). Conversely, a high rating does not ensure profitability if that particular species is tapped; if temperatures are low the resin will not flow, no matter how good a yielder the species may be intrinsically.

A relatively recent development is the interest shown by foresters in *Pinus* hybrids. By controlled crossing of appropriate species it is possible to combine the desirable features of one species with those of another at the expense of the less favourable attributes. Recent work in South Africa, following earlier research in Australia, has confirmed the potential for improved wood production of *P. elliottii* x *P. caribaea* hybrids over the parent species. Of equal importance to naval stores production, was the finding that the hybrid also gives enhanced resin yields. In the future, *Pinus* hybrids may become a valuable resource for combined wood and resin production, if they are found to be suitable.

In spite of the generalizations which can be made about the suitability of certain pine species for naval stores production, intrinsic variation in resin properties can also occur within a species according to the natural population from which the trees are derived, i.e., the provenance origin; *P. caribaea* shows some variability between and within each of the varieties (var. *caribaea,* var. *hondurensis* and var. *bahamensis*). As resin composition (measured in terms of the turpentine and rosin) is easily determined and is less influenced by environmental factors than yield, most of the available information on provenance variation relates to composition rather than yield. Compositional variation is most often seen in the turpentine and can sometimes be quite marked. The turpentine from one provenance might have a high (and therefore desirable) pinene content, whereas turpentine from a different provenance might be richer in 3-carene. Rosin composition is much more stable within a species than turpentine.

If natural stands of pines are being considered for tapping, it is essential to survey the different areas where it grows in order to determine the extent of any major variation in resin quality; tapping trials at different sites should also be carried out to assess productivity. If plantation pines are derived from different provenances, samples from each provenance should be tested to ensure that they are all suitable for exploitation. Although the variability of turpentine composition may appear to impose constraints on the utilization of a pine resource, in practice it does not, particularly for a small producer. The turpentine is likely to be used locally, in whole form, rather than as a source of chemical isolates for which composition is crucial. Variations in resin yields are far more important.

If individual trees are examined, pronounced differences in resin (turpentine) composition and yields become apparent even within the same provenance. Trees of comparable size growing close to each other (and therefore experiencing identical climatic and edaphic conditions) can yield vastly different amounts of resin. In order to evaluate the productivity of a particular site, tapping trials should be designed to take account of this variability by testing a sufficient number of trees. In spite of the disadvantages, these differences offer some long term scope for improvements in quality and productivity by elite germplasm selection. In a few cases, seed orchards have been established from which superior seed can be purchased (*P. elliottii* in the United States, for example).

2.2 PACKING OF TURPANTINE AND ROSIN

2.2.1 Turpentine

International shipments of turpentine are usually made in container size (20-tonne) bulk tanks. In response to the world-wide concern for adequate safety measures to ensure the safe handling and transportation of materials that are actually or potentially dangerous substances, increasing attention is being paid by importing countries to the packaging and labelling of 'dangerous goods'. As turpentine is a flammable material it is classified under this heading.

Within the European Community, a 1979 Council Directive (79/831/EEC), which has now become mandatory, details 'laws, regulations and administrative provisions relating to the classification, packaging and labelling of dangerous substances'. The Directive requires every package to show the name and origin of the substance, the danger symbol (e.g. a flame in a red diamond indicating a flammable liquid) and standard phrases indicating special risks (e.g. 'flammable') and safety advice. The minimum size and placement of labels is also specified. When dangerous 'substances' are transported they become 'goods', and when conveyed from one country to another they are subject to international regulations according to the means of conveyance. When sending shipments by sea, the regulations of the International Maritime Dangerous Goods (IMDG) code have to be observed. As with dangerous substances, dangerous goods have to be marked with warning labels.

Turpentine is shipped under United Nations number 1299 which means that the container must meet certain requirements; this number falls within Class 3, Packing Group III, and has to be quoted in all shipping documents. A new producer contemplating the export and international shipment of turpentine should obtain more detailed information from national transportation authorities or prospective importers.

When it arrives in the country to which it is being shipped, the importer may divide the consignment into lacquer-lined steel drums for local sales. If the importer is willing to take the turpentine in drums, they should be new galvanized steel drums of about 200 litres (170-185 kg net) capacity. Internal lacquering of the drums is usually preferred, but care should be taken to avoid cracking the lacquer layer when handling because this has an adverse effect on the turpentine.

2.2.2 Rosin

Requirements for the labelling of rosin for transportation into, and within, the European Community are currently (late 1994) under discussion and may not be resolved for some time. Prospective exporters of rosin to the EC or elsewhere are therefore advised to seek up-to-date information from importers in the countries concerned.

Rosin may be packaged in a variety of forms. On discharge from the still, the molten rosin is often fed into new, galvanized steel drums of around 225-250 kg (net) capacity. The drums have domed tops so that after they have been set aside for the rosin to cool and solidify (with resulting contraction in volume), the tops can be hammered flat. Alternatively, flat-topped drums can be filled in two or three stages over several days to allow for the change in volume on cooling. International shipments of rosin are also usually made in container loads. In the larger producing countries in which there are large end- consumers of rosin, transportation of molten rosin in specially designed tank-cars is feasible; this is unlikely, however, to be something which a new, smaller producer would contemplate.

End users are showing a growing preference for less robust forms of packaging to enable easier opening and handling, and in this case, silicone or polypropylene-lined multi-wall paper bags can be used. The sacks can be filled either with molten rosin directly from the still (which is then allowed to cool to form a solid block) or with flakes of solidified rosin. The flakes are formed by discharging hot rosin onto a moving belt; by the time it has reached the end of the line, the rosin has solidified into a thin sheet which can easily be broken up and transferred to bags. For ease of handling, 25 kg bags are a convenient size.

For relatively small naval stores operations, the quantities of rosin produced or the intended markets may not warrant investment in new drums or other forms of more expensive packaging, so simpler ways of handling and transporting the rosin can be used. The molten rosin from the still can be drained either into cardboard boxes supported by suitable frames, or into split drums. Solidified rosin from split drums can be broken into lumps and bagged. The disadvantage of this method is the formation of an appreciable quantity of powdered rosin which is prone to oxidation and discolouration, and which results in a poorer quality product.

STATICAL TABLES

Table 6. Rosin[a]: exports from the People's Republic of China, 1987-92 (tonnes)

	1987	1988	1989	1990	1991	1992
Total	193000	193000	182975	174000	205000	261000

Source: *Customs Statistical Yearbook,* 1992

Note: [a] Believed to be wholly or mainly gum rosin

Table 7. Rosin[a]: exports from Portugal, 1987-92 (tonnes)

	1987	1988	1989	1990	1991	1992
Total	84456	59068	54258	57107	47050	26069
of which to:						
France	13107	8059	10448	9091	7655	5068
Germany	22156	15454	15687	20518	18493	9535
Netherlands	9590	8338	4302	4213	3368	1994
Italy	9122	7005	7657	8894	6882	2804
UK	5687	5028	3342	3122	1831	1520
Belgium/Luxembourg	907	434	289	698	325	471
Spain	14059	8890	7250	5664	3997	649
Switzerland	356	412	315	400	369	258
Austria	485	428	181	275	269	354
Japan	300	263	193	193	298	315
USA	3016	2471	2311	1985	1592	1389
Canada	408	169	476	180	403	111
Venezuela	1224	100	106	140	140	140
South Africa	1115	337	224	120	80	135
Morocco	830	302	547	402	641	679
Other countries	2094	1378	930	1212	707	647

Source: *Eurostat* Notes: [a] Defined as 'rosin obtained from fresh oleoresins' or 'gum rosin' [excludes other types of rosin and rosin derivatives

Table 8. Rosin[a,b]: exports from Indonesia, 1987-92 (tonnes)

	1987	1988	1989	1990	1991	1992
Total	14966	22103	7380	14562	17480	23274
of which to:						
Germany	-	-	-	18	696	653
Netherlands	-	126	-	342	1397	1920
Italy	-	350	36	288	936	1453
UK	-	126	54	36	108	40
Belgium/Luxembourg	-	-	-	-	-	346
Portugal	-	-	-	-	340	1056
Spain	-	-	-	-	38	1709
Greece	-	-	-	36	36	125
Turkey	-	-	-	18	36	594
India	5645	5294	1310	5937	3290	1795
Bangladesh	386	474	54	144	54	454
Pakistan	-	791	-	630	15	913
Sri Lanka	-	-	-	72	-	113
Japan	2786	4822	4420	2520	4392	2856
Taiwan, Prov. of China	3417	5660	702	1574	1088	2451
Singapore	1388	2115	492	225	239	352
Korea, Rep. of	522	594	162	1166	2282	2072
Thailand	750	499	101	1085	742	595
Philippines	54	864	50	176	387	650
Australia	-	76	-	144	186	1116
USA	-	16	-	95	614	1015
Mexico	-	Na	-	-	-	55
Colombia	-	Na	-	-	-	335
Ecuador	-	Na	-	-	-	72
Egypt	-	-	-	-	528	96
Other countries	18	296	0	56	76	438

Source: *Indonesia Foreign Trade Statistics*

[a] Defined as 'pine resin' but believed to be wholly or mainly gum rosin
[b] Additional, small quantities tare classified under 'rosin'. Totals are: nil (1987), na (1988), 148 (1989), 607 (1990), 404 (1991), 104 (1992); in each case, most went to India.
na = Not available

Table 9. Rosin [a,b]: exports from Brazil, 1987-93 (tonnes)

	1987	**1988**	**1989**	**1990**	**1991**	**1992**	**1993**
Total	962	11682	13843	8451	8330	10384	13502
of which to:							
Germany	101	490	Na	15	na	na	na
Netherlands	120	1779	Na	1772	na	na	na
Italy	-	177	Na	20	na	na	na
UK	40	925	Na	235	na	na	na
Belgium	-	84	Na	38	na	na	na
Portugal	-	415	Na	-	na	na	na
Spain	-	60	Na	79	na	na	na
Japan	-	36	Na	779	na	na	na
Singapore	10	10	Na	74	na	na	na
USA	477	4531	Na	3938	na	na	na
Mexico	-	-	Na	387	na	na	na
Uruguay	135	326	Na	302	na	na	na
Chile	42	705	Na	425	na	na	na
Ecuador	30	10	Na	-	na	na	na
Venezuela	-	1598	Na	156	na	na	na
Peru	-	103	Na	120	na	na	na
Argentina	-	-	Na	25	na	na	na
South Africa	4	335	Na	40	na	na	na
Other countries	3	98	Na	46	na	na	na

Source: National trade statistics

Notes: [a] Defined as 'colofonias' [excludes rosin derivatives]
[b] Believed to be wholly or mainly gum rosin
na = Not available

Table 10. Rosin[a]: exports from the United States, 1989-93 (tonnes)

	1989	1990	1991	1992	1993
Total	1808	1087	1274	1109	820
of which to:					
Germany	91	122	35	-	19
Netherlands	30	-	5	-	4
Italy	5	22	17	17	-
UK	-	-	83	-	57
Belgium	-	-	101	-	-
Lebanon	-	-	-	-	95
Pakistan	-	-	-	15	71
Japan	480	428	477	51	258
Singapore	7	1	18	6	22
Thailand	23	11	11	-	-
Philippines	9	8	7	-	27
Canada	116	-	-	-	-
Mexico	78	191	38	706	69
El Salvador	60	15	11	27	-
Panama	5	54	28	32	-
Venezuela	2	80	232	49	35
Peru	10	2	49	32	15
Colombia	36	7	45	-	-
Argentina	-	-	-	-	95
Egypt	750	-	-	-	-
Kenya	-	-	-	139	-
South Africa	-	85	-	-	18
Other countries	106	61	117	35	35

Source: National trade statistics

Note: [a] Defined as 'gum rosin' [separate from wood rosin and tall oil rosin]

Table 11. Rosin[a]: imports into the European Community, 1987-92 (tonnes)

	1987	**1988**	**1989**	**1990**	**1991**	**1992**
Total	151986	147897	141961	146075	160354	188036
of which from:						
France	672	574	362	544	496	2276
Germany	1254	1551	1835	1405	1782	1989
Netherlands	395	1796	2889	1624	2490	5213
UK	69.	58	215	593	1276	2068
Belgium/Luxembourg	472	407	401	465	1677	3243
Portugal	71875	54442	50219	51654	41551	23142
Spain	509	292	412	457	478	520
Yugoslavia, former	5187	8539	312	-	45	-
Greece	165	91	81	157	302	300
Soviet Union, former	23	347	2894	977	952	303
Russia	ns	ns	ns	ns	ns	942
China, People's Rep. Of	65468	66725	66459	76843	94790	123895
Indonesia	-	404	180	579	4664	10872
Hong Kong	329	1879	161	304	234	1389
USA	763	1303	716	689	799	1110
Mexico	1221	835	585	142	197	73
Honduras	2809	2308	3352	2749	2841	3463
Brazil	101	3045	5941	2063	2708	5009
Argentina	15	42	973	241	76639	-
Venezuela	-	-	66	1316	20	-
South Africa	-	-	-	-	-	81
Other countries	659	3259	3908	3273	2976	1509
of which to:						
France	20888	19861	17396	18211	21725	21979
Germany	49069	47425	44833	54487	54553	61053
Netherlands	33644	34025	38023	33445	39564	43811
Italy	16036	13601	12846	12292	15083	15639
UK	15546	18386	14033	13335	11323	12658

Belgium/Luxembourg	2087	1970	2228	3121	3038	5758
Spain	14037	10519	11158	8999	8607	13994
Portugal	12	1410	503	809	3115	8875
Greece	2	-	9	-	-	134
Denmark	329	310	356	184	794	1029
Ireland	336	390	576	1192	2552	3106

Source: *Eurostat*

Notes:

[a] Defined as 'rosin obtained from fresh oleoresins' or 'gum rosin' [excludes other types of rosin and rosin derivatives]
ns = Not specifie

Table 12. Rosin [a]: imports into Japan, 1987-93 (tonnes)

	1987	**1988**	**1989**	**1990**	**1991**	**1992**	**1993**
Total	71011	82416	78911	60844	74442	68927	75303
of which from:							
China, People's Rep. Of [b]	60473	66399	59589	48328	60697	58046	61755
Taiwan, Prov. of China	-	230	-	-	-	522	630
Indonesia[b]	3372	5038	9005	3474	5656	4968	8172
Hong Kong	118	200	1022	535	1150	1531	212
Viet Nam[b]	-	-	-	-	300	815	821
New Zealand	1885	1375	1491	1374	1163	845	1003
Portugal[b]	248	298	263	158	333	333	263
USA	4809	8663	7429	6072	4416	1554	2379
Brazil[b]	-	36	97	798	634	20	20
Other countries	106	177	15	105	93	293	48

Source: *Japan Exports and Imports*

Notes:

[a] Defined as 'rosin' or 'rosin and resin acids' [excludes salts, ester gums and other derivatives]
[b] Believed to be wholly or mainly gum rosin

CHAPTER 3 RESIN INDUSTRY: INTRODUCTION

3.1 RESIN

Most conifers will exude resin if wounded. Others will exude resin spontaneously from branches and cones. Several genera of conifers produce resin in copious quantities, which are then harvested and put to a wide variety of uses. These have made resin one of the most important non-wood products from conifers. The following sections describe some of the more important sources and uses of conifer resins.

3.2. Resin from pines

The resin harvested from various species of *Pinus* is undoubtedly the oldest and most important of the non-wood products from conifers. Therefore, only a brief review will be given in this paper on pine resins, complemented by a review of resins obtained from other conifers. Resins obtained from non-coniferous trees.

3.3. Sources of resin

Resin products from pines are commonly called **naval stores**. This term dates back to the days when the British Royal Navy used large quantities of resin products from pines to waterproof ships. Today, three classes of naval stores are recognized based on their source

1. Gum Naval Stores - These are obtained by tapping the trunks of living pine trees. This is the traditional source of resin and is a labour intensive process.

2. **Sulphate Naval Stores** - Are obtained during the conversion of pine wood chips to pulp via the sulphate or Kraft pulping process. Sulphate turpentine is condensed from the cooking vapours. A product known as **tall oil** is obtained from alkaline liquors and fractionated into products such as tall oil rosin and tall oil fatty acids.

3. Wood Naval Stores - Are obtained from resin saturated pine stumps long after a tree has been felled.

3.4 Products of resin

Distillation of pine resin yields two products: turpentine and rosin.

3.4.1 Turpentine

Turpentine, like rosin, is a very versatile raw material. At one time turpentine was a very important solvent and thinner for paint and varnish. In recent years this use has declined drastically, both on account of substitution by cheaper petroleum-derived solvents (white spirits) and because of the growth of paints based upon polymeric latexes. Whereas in the past turpentine was used mostly in its natural form, today most turpentine is further processed into its various constituents before use It is a clear liquid with a pungent odors and bitter taste and is composed of a number of organic compounds, primarily a series of volatile fractions known as terpenes. The chemical composition of turpentine can vary significantly depending on the species of *Pinus* from which it is harvested. In some pines, the terpene composition is relatively simple and consists mainly of two common terpenes: alpha and beta pinenes. Other pine species contain different terpenes, which may significantly affect the composition and use of the turpentine.

- Turpentine, which comes from pine trees, contains 75-90% resin and 10-25% oil.
- The oil of turpentine is the principle product of turpentine, widely used as a solvent or thinner for paints and varnishes.
- Turpentine is a fluid obtained by the complex distillation of resin obtained from trees, mainly various species of pine (Pinus).
- It is composed of terpenes, mainly the monoterpenes alpha-pinene and beta-pinene.
- Alternative names are wood turpentine, spirit of turpentine, oil of turpentine and gum turpentine.
- It is also known colloquially as just turps, although this more often refers to turpentine substitute (or mineral turpentine).
- Boiling in large tubs takes place at 155 degrees Celsius to obtain turpentine oil.

- Resin ducts in the bark and outer wood are tapped in species of pine (Pinus, Family Pinaceae) to obtain resin for the distillation of turpentine and other paint spirits.
- Medically it is a stimulant and diuretic and is capable of destroying various intestinal parasites.
- An example of the use of turpentine in medicine is Watkins White Cream Liniment, the active ingredients of which 3% Camphor are and 9% turpentine. The remainder of the ingredients is inactive. (Encarta)
- International shipments of turpentine are usually made in container size (20-tonne) bulk tanks.
- Gum Spirits of Turpentine is a traditional oil painting solvent and medium for thinning oil color and varnishes.
- This high quality Brazilian gum spirits of turpentine readily improves flow and dissolves wet oil color. Great for cleaning brushes and tools used with oil color.
- Best Klean Gum Spirits of Turpentine evaporates more readily than traditional thinners. Available in 4, 8, 16, and 32 oz. size can.
- In response to the world-wide concern for adequate safety measures to ensure the safe handling and transportation of materials that are actually or potentially dangerous substances, increasing attention is being paid by importing countries to the packaging and labelling of 'dangerous goods'.

Table 13 Pines that are important commercial sources of rosin

Species	*Countries where important*
P. brutia	Turkey
P. caribaea	Kenya*, South Africa*, Venezuela*
P. elliottii	Argentina*, Brazil*, Kenya*, S.Africa*
P. halepensis	Greece
P. kesiya	China
P. massoniana	China
P. merkusii	China, Indonesia, Vietnam
P. oocarpa	Honduras, Mexico
P. pinaster	Portugal
P. radiata	Kenya*
P. roxburghii	India, Pakistan
P. sylvestris	Lithuania, Poland, Russia

3.5 Uses of turpentine oil and rosin

For many years, both rosin and turpentine were used in an unprocessed form in the manufacture of soaps, papers, paints and varnishes. Today, they are the raw material used in the production of a wide range of products. Most rosin is presently modified and used in paper sizing, adhesives, printing inks, rubber compounds and surface coatings Rosin is also applied to the bows of string instruments and to belting to reduce slipping. It is also used in brewing and mineral beneficiation. The uses of turpentine oil and rosin are given in the **Table 14.**

Table 14 Principle uses of turpentine and rosin

Turpentine	Rosin
Chemicals and pharmaceuticals	Paper and paper sizing
Gums and synthetic resins	Chemicals and pharmaceuticals
Paint, varnish and lacquer	Ester gums and synthetic resins
Products for railroads and shipyards	Paint, varnish and laquer
Shoe polish and related materials	Soap
Rubber	Linoleum and floor coverings
Printing inks	Adhesives and plastics
Adhesives and plastics	Oils and greases
Asphaltic products	Rubber
Furniture	Printing inks
Insecticides and disinfectants	Shoe polish and related materials

Table 15.Major rosin and turpentine producing countries.

(Country production in percentage of World Average Total Production)

Country	Rosin (%)	Turpentine (%)
USA	47.0	42.5
USSR	15.8	13.3
China	8.6	14.4
Portugal	7.2	6.4
Mexico	3.7	2.9
Spain	3.0	3.5
France	2.9	3.0
India	2.8	2.2
Poland	2.2	2.1
Greece	1.9	2.0

Table 16. Major crude resin, rosin and turpentine producing countries, 1990-1993 (Country production in percentage of World Average Total Production)

Country	Crude Resin (%)	Rosin (%)	Turpentine (%)
China	59	60	50
Indonesia	10	10	12
Russia	9	9	9
Brazil	7	6	8
Portugal	3	3	5
India	3	3	4
Argentina	3	3	4
Mexico	3	3	4
Honduras	<1	1	1
Venezuela	<1	<1	<1
Greece	<1	<1	<1
South Africa	<1	<1	<1
Vietnam	<1	<1	<1
Others	<1	<1	<1

Table 17. Estimated exports of gum rosin and turpentine, 1990-1994

Country	Rosin (Tonnes)	Turpentine (Tonnes)
China	277 000	5 500
Indonesia	46 000	7 500
Russia	1 000	500
Brazil	13 000	3 000
Portugal	26 000	6 000
Argentina	10 000	2 000
Mexico	5 000	?
Honduras	5 000	500
Vietnam	1 000	--
Total	384 000	25 000

3.6. WASTE GENERATION IN THE RESIN INDUSTRY

Basically in the resin industry, only three types of wastes are generated.

(a) Sakki (pine needles, bark pieces & other foreign Particles)
(b) Waste water
(c) Dirty resin mixed with soil

CHAPTER 4 ROSIN AND TURPENTINE INDUSTRY, BILASPUR

4.1 Location and profile

The industry is located in (ZABLI) about 4km. away from Bilaspur (HP) on the Kullu Manali road. In the industry there are about 100 employees. The total production of rosin in this industry is about 65000 tones, per year. It is well settled industry in the region, which was started in 1964. The prepared rosin is supplied in all over the India. The rosin is not exported. There are only two products which are formed in the industry. These are Rosin and turpentine oil. The total production of turpentine oil is about 35000 liter/yr. There is also a well established laboratory in the industry for the testing of the raw resin as well as prepared rosin.

4.2. Processes occurred in the industry

Various processes for the preparation of the rosin in the industry are discussed below:

4.2.1. Random sampling

The raw material is coming from all over the Himachal pardesh, packed in the tins. This raw material contains a lot of impurities such as bird's excreta. Soil, pines leaves, bark pieces, spines, and other foreign material, which decrease the quality of the material. So if there is 500 tin in one truck then from them 10 samples are taken randomly from 10 tins. These are mixed and then the impurities will be checked in the laboratory. It gives the total impurities present in the raw material. The sample is initially mixed and put into the sakki plant where the steam is given to the sample for the melting then it is screened through a screen. It gives the total sakki present in the sample and then the sample is going to the lab where some amount of it is taken and placed in the muffle furnace. After 2 hrs all the resin is burned and the soil is remained in the china dish. The weight of the soil gives the amount of soil present in the sample

4.2.2 Resin store

There is a resin store having the capacity of 1.5 lakhs tins. After the random sampling these tins are carried to the resin store. From these stores, the raw resin tins are carried to the resin pits.

4.2.3 Resin pits

There are two resin pits having a capacity of 400 tins each. The resin tins are inverted into the resin pits for the further processing. In the resin pits the resin are diluted with some turpentine oil to decrease the viscosity so as to ease the handling.

4.2.4 Heating chamber

The empty tins which are having the residual resin are then inverted on a trolley and the trolley is taken to a heating chamber where steam is applied to the empty tins and the residual resin melted. There is a small tank with sieve under the trolley. The melted resin is collected in the tank and it is sent for the further processing.

4.2.5 Process of distillation

The resin contained in about 400 Tins (7.2 Tons.approx.) is emptied in to the Resin Pit. During winter resin is a bit hard to work, so 100-200 Litres of Turpentine Oil is mixed to dilute this resin. The Screw Elevator lifts this resin along with sakki (pine needles, bark pieces & other foreign particles) to the mixing Vat. The capacity of the Mix Vat is 350-400 tins i.e. about 7.2 Tons. of resin. The resin is heated indirectly in this vat by passing steam through copper coils for 4 to 6 hours to melt the resin in it. The temperature is maintained up to 95^0 C. Here 600-1200 Liters of Turpentine Oil (depending on the quality of resin) is mixed in the mixing vat. along with 5 kg. common Salt. The molten resin is then stirred mechanically. The molten resin is then passed through 40-mesh (in one square inch, there are 40 openings) stainless steel wire net to remove bigger impurities like pine needles, bark pieces etc.

From here the resin is pumped by centrifugal pump into a Rest Vat. The capacity of each rest vat is about 7.2 Tons. The resin is allowed to rest in the rest vat from 18 hours to 20 hours. During this rest period, the impurities and dust if present, settle down by gravity. The dust/impurities are removed through a bottom valve and sent for processing separately as inferior grades of Rosin. About 1.7 to 1.8 Tonnes of resin from rest vat is carried to the compression chamber.

In the Distillation Kettle, the resin is cooked for 1-2 hours by indirect steam at a pressure of 10 kgs/cm^2. In Distillation Kettle, the molten resin remains inside the copper tubes and steam remains in the shell. In this process the Turpentine oil and moisture present in the resin get evaporated and condensed in the condenser. Turpentine oil is collected in a T.Oil Separator.

The Rosin left in the distillation kettle is taken out at 165^0 C & collected in trolleys, wherein about 100-200 grams of Oxalic Acid (depending on the quality of resin) is mixed to increase the transparency / shine of Rosin. This Rosin is then packed in Tin Patra Barrels of 200 Kg capacity.

These items i.e. Rosin and Turpentine Oil are also called Gum Naval Stores in American markets. This is based on the historical use of rosin for making boats water proof.

4.3 Rosin

Rosin is a brittle, faintly aromatic solid, which may be transparent or slightly translucent and possesses a glassy fracture. It is insoluble in water, but soluble in many organic solvents including alcohols, ethers and esters, and aliphatic, aromatic and chlorinated hydrocarbons.

All rosin is purchased on a color basis, which varies from pale amber to black. The lighter the color, the more valuable the rosin. The procedure for sample and color grading is fairly simple: a portion of rosin is formed into a cube of 7/8 inch (22mm) sides. This cube is placed inside the cabin of Lovibond Tintometer and Standard Color of the specific grade is compared with that of the cube. The standard color is obtained by combination of glass slides of different shades of Red, Blue and Yellow. This is as per the procedure laid down in IS 553:19.

4.3.1 Grading of rosin

After the processing of the resin, the grading should be done so as to check the quality. The grading should be done on the basis of color, and transparency. There are nine grade of rosin, which are having their different properties, color and quality. The highly transparency shows the high quality of the rosin. The low transparency shows that this form of rosin is of low grade and it can be used in the leather works, leathers polish etc. These grades are given below;

(a) X grade
(b) WW grade
(c) WG grade
(d) N grade
(e) M grade
(f) K grade
(g) H grade
(h) B grade
(i) D grade

Table:18 The properties of these grades .

GRADE X			
S.No.	Characteristic	BIS Requirement for type Extra Pale	Rosin Sample of R & T Factory, Extra Pale
1	Grade	X	X
2	Color Value ((Red/Yellow)	1.35,13.0	1.35,13.0
3	Softening point, ^{0}C. Min.	70	72 -75
4	Relative density $27^0/27^0$C	1.050 To 1.080	1.061-1.065
5	Acid Number, Min.	160	165-173
6	Saponification Number, Minimum	165	170-183
7	Volatile matter percent by mass, Max	1.5	0.365-1.000
8	Ash content, percent by mass Max	0.05	0.02 -0.04
9	Matter insolvable in toluene, percent by mass,	0.10	0.04 -0.08
10	Unsponifiable matter, percent by mass, Max	6	2.5 - 5

GRADE WW			
S.No.	Characteristic	BIS Requirement for type Pale	Rosin Sample of R & T Factory, Pale
1	Grade	WW	WW
2	Color Value (Lovibond) (Red/Yellow)	1.85,19.5	1.85,19.5
3	Softening point, ^{0}C. Min.	70	72 - 75
4	Relative density $27^0/27^0$C	1.0520 to 1.0820	1.061-1.072
5	Acid Number, Min.	155	165-171
6	Saponification Number, Minimum	160	170-183
7	Volatile matter percent by mass, Max	2.0	0.380-1.2000
8	Ash content, percent by mass Max	0.2	0.03-0.10
9	Matter insolvable in toluene, percent by mass,Max	0.40	0.06 -0.20
10	Unsponifiable matter, percent by mass, Max	6	2.5 - 5

GRADE WG			
S.No.	Characteristic	BIS Requirement for type Pale	Rosin Sample of R & T Factory, Pale
1	Grade	WG	WG
2	Color Value (Lovibond) (Red/Yellow)	2.6,30	2.6,30
3	Softening point, ^{0}C. Min.	70	72 -74
4	Relative density $27^0/27^0$C	1.0520 to 1.0820	1.065-1.075
5	Acid Number, Min.	155	162-170
6	Saponification Number, Minimum	160	170-180
7	Volatile matter percent by mass, Max	2.0	0.400-1.2000
8	Ash content, percent by mass Max	0.2	0.03-0.10
9	Matter insolvable in toluene, percent by mass,Max	0.40	0.06 -0.20
10	Unsponifiable matter, percent by mass, Max	6	3 - 5.2

GRADE N			
S.No.	Characteristic	BIS Requirement for type Pale	Rosin Sample of R & T Factory, Pale
1	Grade	N	N
2	Color Value (Lovibond) (Red/Yellow)	3.6,41	3.6,41
3	Softening point, 0C. Min.	70	72 -74
4	Relative density 270/270C	1.0520 to 1.0820	1.065-1.075
5	Acid Number, Min.	155	162-170
6	Saponification Number, Minimum	160	165-175
7	Volatile matter percent by mass, Max	2.0	0.500-1.2000
8	Ash content, percent by mass Max	0.2	0.05-0.10
9	Matter insolvable in toluene, percent by mass,Max	0.40	0.10 - 0.20
10	Unsponifiable matter, percent by mass, Max	6	3 - 5.2

GRADE M			
S.No.	Characteristic	BIS Requirement for type Medium	Rosin Sample of R & T Factory, Medium
1	Grade	M	M
2	Color Value (Lovibond) (Red/Yellow)	4.9,51	4.9,51
3	Softening point, 0C. Min.	70	72 -74
4	Relative density 270/270C	1.0520 to 1.0820	1.065-1.080
5	Acid Number, Min.	155	160-165
6	Saponification Number, Minimum	160	162-170
7	Volatile matter percent by mass, Max	2.0	0.700-1.000
8	Ash content, percent by mass Max	0.2	0.05-0.10
9	Matter insolvable in toluene, percent by mass,Max	0.40	0.10 -0.20
10	Unsponifiable matter, percent by mass, Max	6	3 - 5.5

GRADE K			
S.No.	Characteristic	BIS Requirement for type Medium	Rosin Sample of R & T Factory, Medium
1	Grade	K	K
2	Color Value (Lovibond) (Red/Yellow)	6.2,60	6.2,60
3	Softening point, 0C. Min.	70	72 -74
4	Relative density 270/270C	1.0520 to 1.0820	1.065-1.080
5	Acid Number, Min.	155	160-165
6	Saponification Number, Minimum	160	160-170
7	Volatile matter percent by mass, Max	2.0	0.8-1.000
8	Ash content, percent by mass Max	0 .2	0.05 -0.10
9	Matter insolvable in toluene, percent by mass,Max	0.40	0.10 -0.25
10	Unsponifiable matter, percent by mass, Max	6	3.5 - 5.5

GRADE H			
S.No.	Characteristic	BIS Requirement for type Medium	Rosin Sample of R & T Factory, Medium
1	Grade	H	H
2	Color Value (Lovibond) (Red/Yellow)	12,100	12,100
3	Softening point, 0C. Min.	70	71 -75
4	Relative density 270/270C	1.0520 to 1.0820	1.065-1.080
5	Acid Number, Min.	155	160-165
6	Saponification Number, Minimum	160	160-165
7	Volatile matter percent by mass, Max	2.0	1.0-1.5000
8	Ash content, percent by mass Max	0.2	0.05 -0.15
9	Matter insolvable in toluene, percent by mass,Max	0.40	0.10 -0.30
10	Unsponifiable matter, percent by mass, Max	6	3.5 - 5.5

GRADE D			
S.No.	Characteristic	BIS Requirement for type Dark	Rosin Sample of R & T Factory, Dark
1	Grade	D	D
2	Color Value (Lovibond) (Red,Yellow,Blue)	75,160,3.0	75,160,3.0
3	Softening point, 0C. Min.	70	72-76
4	Relative density 270/270C	1.0520 to 1.1020	1.072-1.080
5	Acid Number, Min.	155	157-162
6	Saponification Number, Minimum	160	160-165
7	Volatile matter percent by mass, Max	2.0	1.0-1.5000
8	Ash content, percent by mass Max	0.5	0.10 - 0.40
9	Matter insolvable in toluene, percent by mass,Max	1.00	0.20 -0.80
10	Unsponifiable matter, percent by mass, Max	6	4 - 5.5

	GRADE B		
S.No.	Characteristic	No BIS Requirement for type Dark	Rosin Sample of R & T Factory, Dark
1	Grade	B	B
2	Color Value (Lovibond)	No BIS Requirement for type	Nil
3	Softening point, 0C. Min.		72-80
4	Relative density 270/270C		1 .075-1.080
5	Acid Number, Min.		155-160
6	Saponification Number, Minimum		160-165
7	Volatile matter percent by mass, Max		1.0 -2.000
8	Ash content, percent by mass Max		0.3 -1.000
9	Matter insolvable in toluene, percent by mass,Max		0.6 -2.00
10	Unsponifiable matter, percent by mass, Max		4 - 7.8

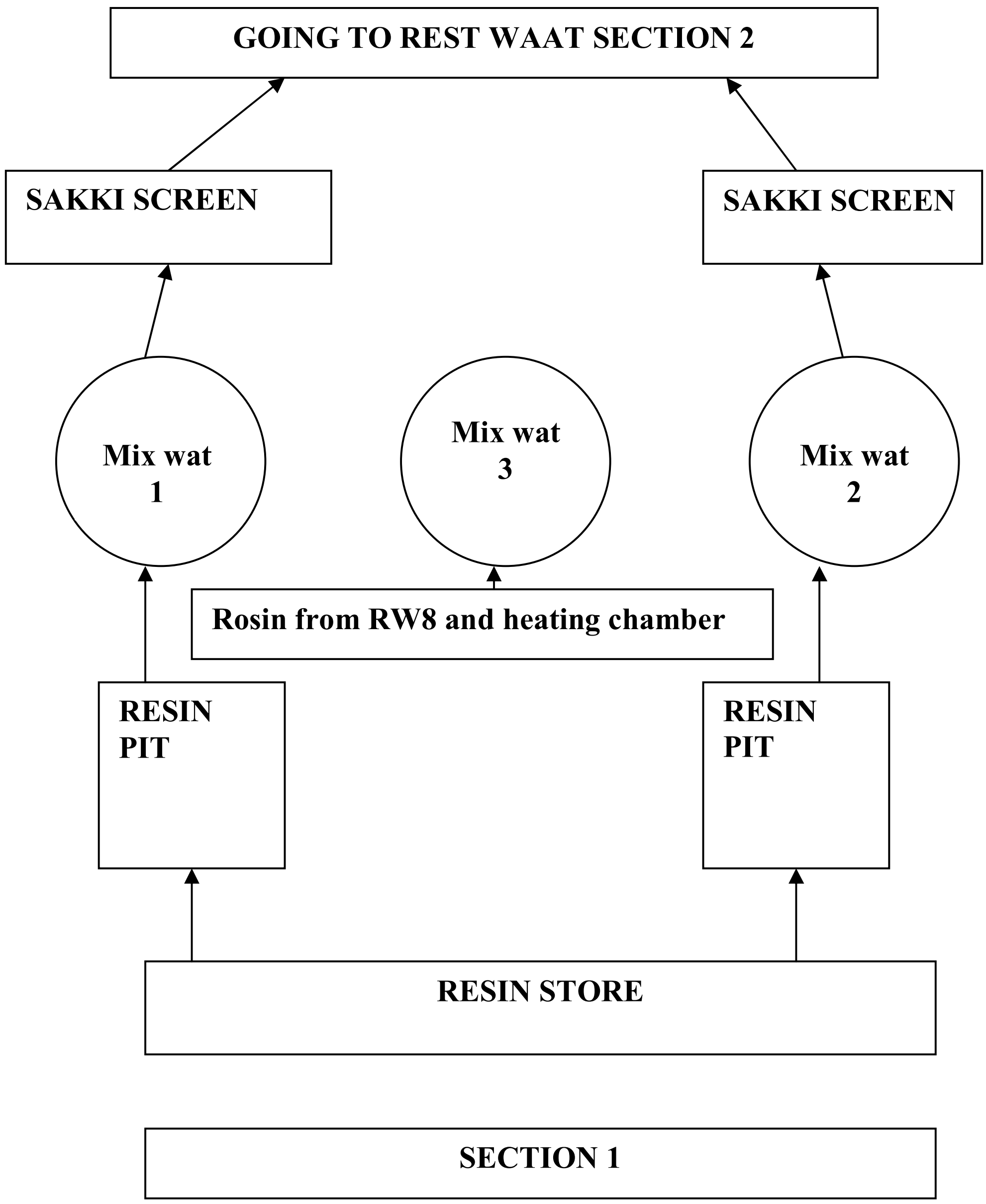
4.3.2. Description of all the sections of the processes occurred in the industry

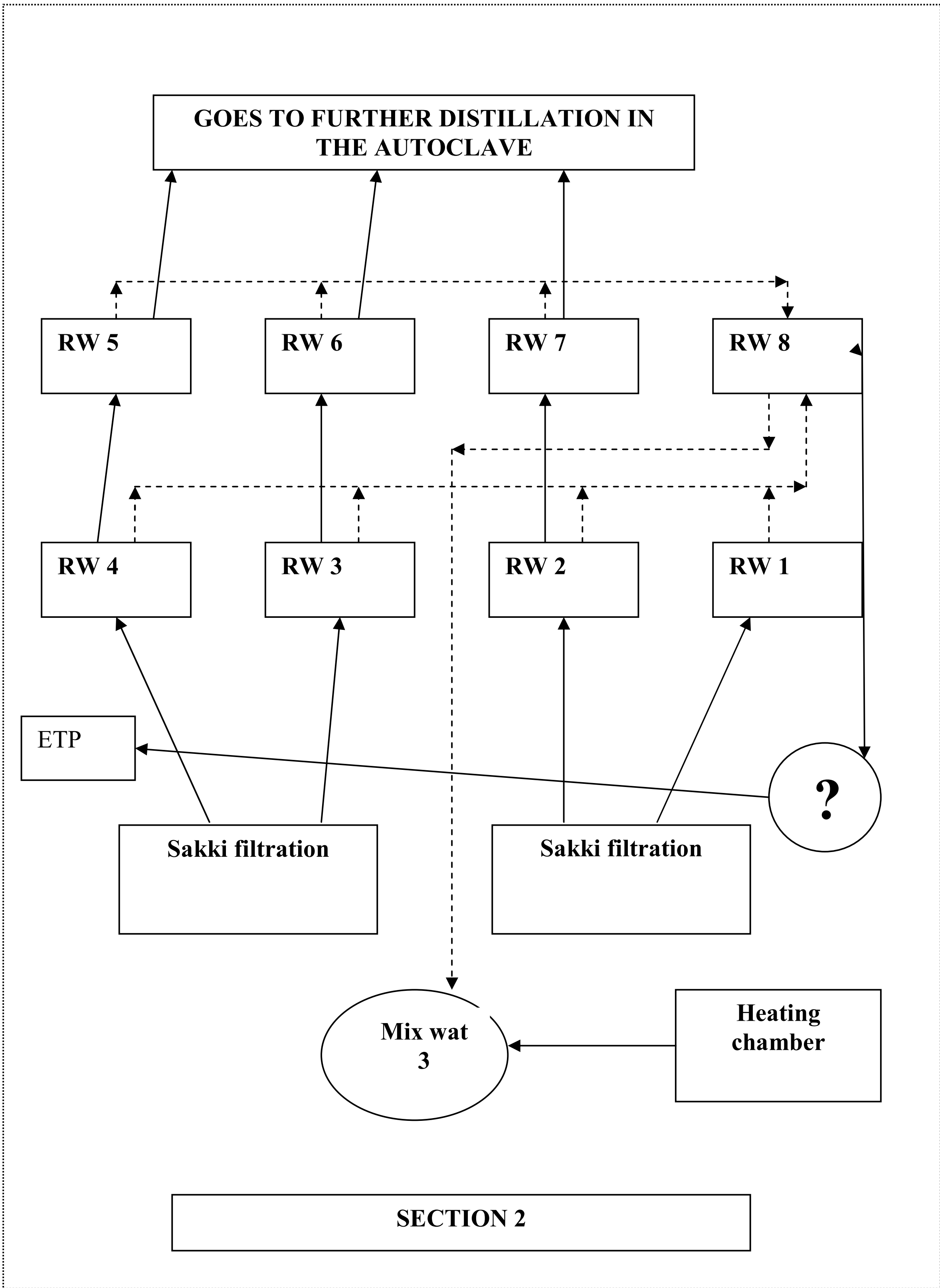
There are three sections in the rosin and turpentine industry for the processing of resin. The flow diagrams of all the three sections are given below:

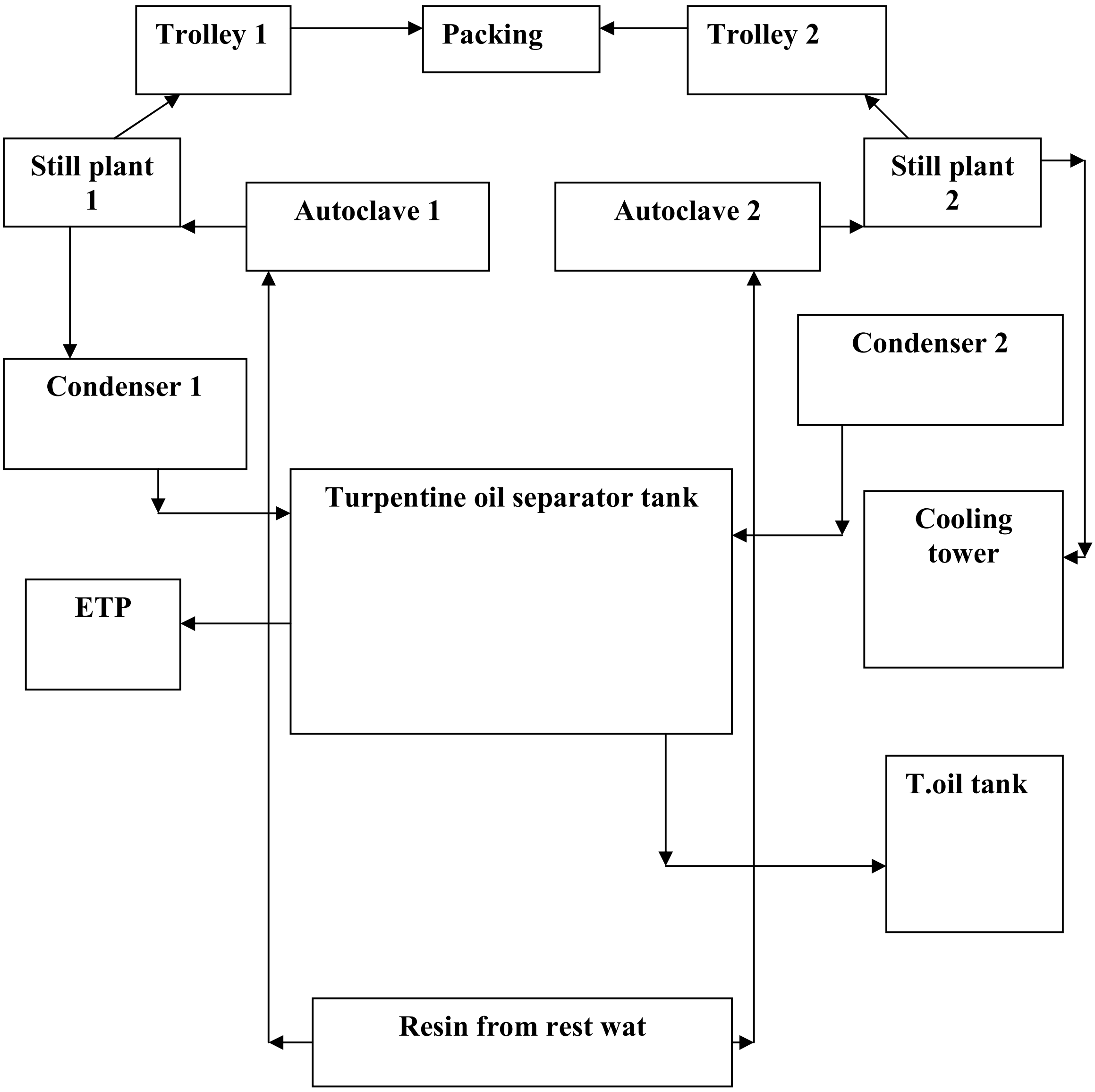
Section 1: Shows the loading of resin from the resin store and then to the mix wat 1 and mix wat 2. Here steam is being applied to the resin thus raising its temperature to 600^0C resulting in the melting of resin. After that it goes to sakki filtration and the loading of resin is being done in various rest wats.

Section 2: In this section 12 to 16 hours rest is given to the resin. Then the supernatant resin is migrated in the autoclave for the further distillation and the impure settled resin is migrated to the rest wat (RW8). After that the impure resin from the rest wat 8 is migrated in the mix wat 3. The impure resin from the heating chamber is also added to the mix wat 3.

Section 3: The flow diagram of section 3 shows the loading of resin in the autoclave and from that to the still plant 1and 2. From the still plant the resin is boiled and loaded in the trolley 1 and 2. From these trolleys the resin is sent for packing. The vapors of T. oil generated in the still plant are then condensed in the condenser. From the condenser, the oil and water is migrated to the T. oil separator tank. From the T. oil separator tank the T.oil is collected in the T. oil tank and the water is taken to the ETP.


GOING TO REST WAAT SECTION 2
SAKKI SCREEN
SAKKI SCREEN
Mix wat 1
Mix wat 3
Mix wat 2
Rosin from RW8 and heating chamber
RESIN PIT
RESIN PIT
RESIN STORE
SECTION 1


GOES TO FURTHER DISTILLATION IN THE AUTOCLAVE
RW 5
RW 6
RW 7
RW 8
RW 4
RW 3
RW 2
RW 1
ETP
?
Sakki filtration
Sakki filtration
Mix wat 3
Heating chamber
SECTION 2


Trolley 1
Packing
Trolley 2
Still plant 1
Autoclave 1
Autoclave 2
Still plant 2
Condenser 1
Condenser 2
Turpentine oil separator tank
Cooling tower
ETP
T.oil tank
Resin from rest wat

SECTION 3

CHAPTER 5 EFFLUENT TREATMENT PLANT

The various processes used in the industry like filtration, distillation, boiling and mixing, generate either solid waste or liquids. The majority of the time the effluent coming from the industries contains some soil, rosin, rosin contaminated with soil and some turpentine oil. So treat this waste water some concerns are there in terms of removing of turpentine oil, rosin, and rosin contaminated with soil. In the effluent treatment plant in rosin industry Bilaspur the following components are used in the treatment of effluent.

- Flow equalization tank
- Oil and grease scrubber
- Neutralization tank
- Primary settling tank
- Aeration tank
- Tube settle

Table 19. Data of various parameter of the influent for rosin and Turpentine industry Bilaspur

Parameter	Values
BOD	1900 mg/liter
COD	6000 mg/liter
TDS	3500 mg/liter
TSS	1000 mg/liter
TS	5000 mg/liter
pH	3.0

5.1. Flow equalization tank

The average flow of the effluent from the industry is about 10000 liter /day. But due to certain fluctuations, the flow is not continuous. The flow is varying from time to time. So the flow equalization tank is needed.

5.2 Oil and grease scrubber

From the flow equalization tank, the effluent is entered into the oil and grease scrubber tank. Here oil floats on the water surface and skimmed off. After some time the settled sludge from the Rest Watt (RW8) (containing some rosin) also comes into the oil scrubber tank. This rosin is also floating on the surface of the water. The oil is skimmed off from the tank and collected in another tank from where it is taken for further treatment.

5.3 Neutralization tank

Generally the pH of the effluent when it is entered into the ETP is 2.0. With this acidic pH there is urgent requirement for neutralization. Normally about 20 ml of 1 N NaOH solution is needed for neutralization of one litre of the effluent. The volume of the tank is 100 L so appox. 4 kg caustic is dissolved in 100 liter water. There is an impeller connected with a motor for rapid mixing in the neutralization tank. The NaOH solution is completely mixed in the effluent and the pH is increased up to 7. At least 20 liter of the solution is used daily for neutralizing the 10000 liter of the effluent. So one tank of 100 liter NaOH solution is sufficient for 5 days.

Table 20. Data of various parameters after neutralization

Parameter	Values
BOD	800 mg/liter
COD	2200 mg/liter
TDS	2015 mg/liter
TSS	1015 mg/liter
TS	3030 mg/liter
pH	7.5

5.4 Primary settling tank

After the neutralization tank, the effluent is treated in the primary settling tank. Due to the rapid mixing in the neutralization tank, the sediments remain in the suspension. The sediments are settled in the primary settling tank. And that the supernatant is taken to the aeration tank through drain. The settled sediments are now collected in the primary sludge tank.

5.5 Aeration tank

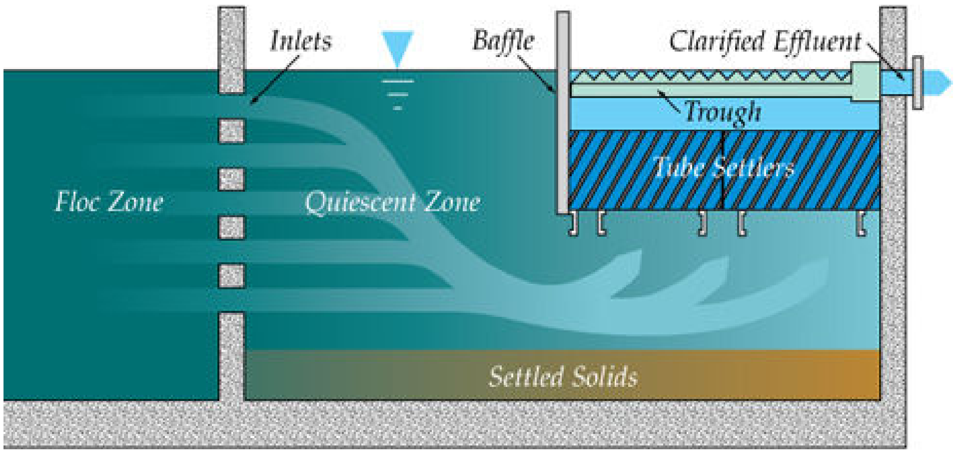
The supernatant from the primary tank is now allowed to enter in the aeration tank. There are two aeration tanks. There are diffusers in the aeration tank for the aeration. The biomass is generated by adding cow dung (appox. 40 Kg) in the aeration tank. Urea (3 Kg) is also added for the supply of nitrogen for the biomass. Some amount of Diammonium phosphate appox. One kg (DAP) is also added in the aeration tank. The aerobic bacteria decompose the organic matter present in the effluent.

5.5.1 Diffuser

An air diffusion apparatus for aeration of the media in a liquid filled tank includes an air supply manifold, a drop pipe connected to the air supply manifold, and a diffuser header assembly connected to the drop pipe. The diffuser header assembly has shoes allowing it to roll or slide against the tank walls and bottom during installation and removal. The diffuser header assembly is negatively buoyant during installation and operation of the apparatus, so that attachment of the diffuser header to the bottom or sides of the tank is not required. This results in easy installation and removal of the apparatus without requiring prior removal of the contactor or other obstructions from the tank.

5.6 Tube settler

Tube settlers and parallel plates increase the settling capacity of circular clarifiers and/or rectangular sedimentation basins by reducing the vertical distance a floc particle must settle before agglomerating to form larger particles.



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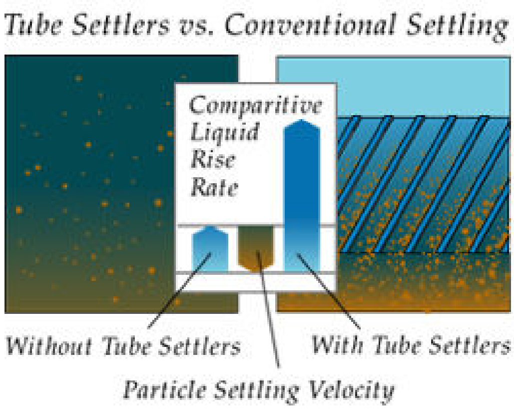


- Tube settlers use multiple tubular channels sloped at an angle of 60° and adjacent to each other, which combine to form an increased effective settling area. This provides for a particle settling depth that is significantly less than the settling depth of a conventional clarifier, reducing settling times.
- Tube settlers capture the settle able fine floc

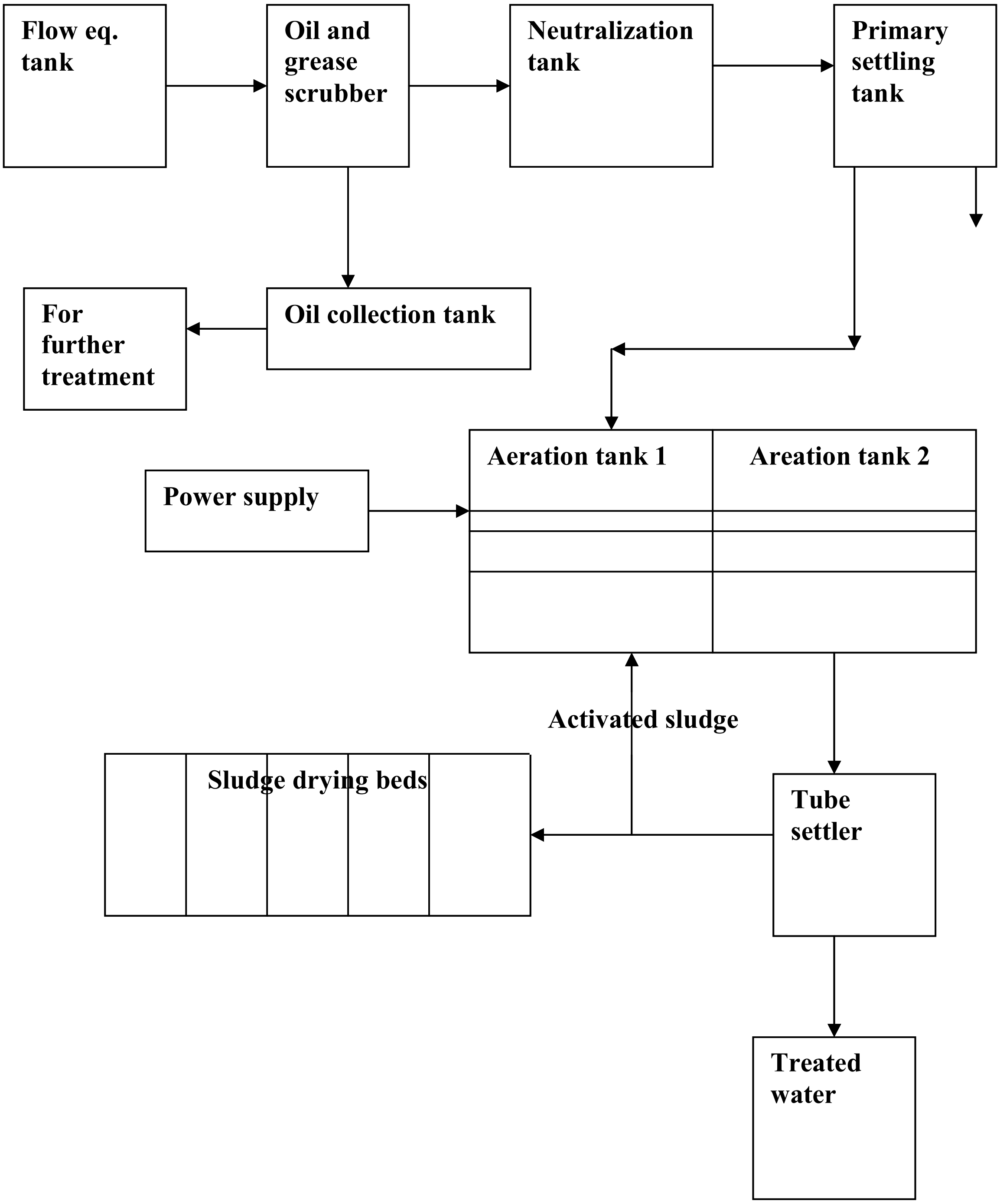
that escapes the clarification zone beneath the tube settlers and allows the larger floc to travel to the tank bottom in a more settleable form. The tube settler's channel collects solids into a compact mass which promotes the solids to slide down the tube channel.

The advantages of tube settlers can be applied to new or existing clarifiers/basins of any size:

- Clarifiers/basins equipped with tube settlers can operate at 2 to 4 times the normal rate of clarifiers/basins without tube settlers.
- It possible to cut coagulant dosage by up to half while maintaining a lower influent turbidity to the treatment plant filter
- Less filter backwashing equates to significant operating cost savings for both water and electricity.
- New installations using tube settlers can be designed smaller because of increased flow capability.
- Tube settlers increase allowable flow capacity by expanding settling capacity and increasing the solids removal rate in settling tanks.

5.7 Sludge drying bed

There are four sludge drying bed in the industry. Digested sewage sludge is usually dewatered before disposal. Dewatered sludge still contains a significant amount of water—often as much as 70 percent—but, even with that moisture content, sludge no longer behaves as a liquid and can be handled as a solid material. Sludge-drying beds provide the simplest method of dewatering. Digested sludge slurry is spread on an open bed of sand and allowed to remain until dry. Drying takes place by a combination of evaporation and gravity drainage through the sand. A piping network built under the sand collects the water, which is pumped back to the head of the plant. After about six weeks of drying, the sludge cake, as it is called, may have a solids content of about 40 percent. It can then be removed from the sand with a pitchfork or a front-end loader. In order to reduce drying time in wet or cold weather, a glass enclosure may be built over the sand beds. Since a good deal of land area is needed for drying beds, this method of dewatering is commonly used in rural or suburban towns rather than in densely populated cities



Effluent Treatment Plant Rosin and Turpentine industry Bilaspur

5.8. Problems occurred at the time of study of ETP of the industry.

- Resin mix with soil.
- Resin entered into the aeration tank
- Falling of leaves in the tube settler.

Problem no. 1

Resin mix with soil:

The melted resin from the mix wat is lifted in the different rest wat, i.e. the rest wat number 1 to 7, but not in the rest wat no.8. In the rest wat number 1 to 7, the resin is kept here for up to 8 to 16 hrs. The resin didn't change to solid form, it remain in liquid form. So at the time of rest, the soil present in the resin settles down in lower part of the rest wat. With this soil some resin also settles down. This resin is then shifted to the no.3. mix wat, where again it is melted or distilled by giving the steam. Then that resin is again shifted to the rest wat no.8. The soil again settles down. The melted resin is shifted to the autoclave. But some resin again get settle down in the lower part of the rest wat. That resin mix with soil is then shifted to the ETP. Where when it enters in the oil and grease separation tank the resin settles down at the bottom of the tank due to gravity. So it is very difficult to separate the resin from that tank. It is highly acidic, so there is high consumption of caustic soda for the neutralization. The other disadvantage is that the resin enters in the neutralization tank and settled down in the neutralization tank. Thus there is no proper neutralization in that tank.

Problem no.2

Resin entered into the aeration tank:

From the neutralization tank the resin enters into the aeration tank. Where the biomass present in the aeration tank cannot decompose that resin. So the decomposition rate is also slow. Due to low pH, it affects the reproduction of the biomass because the micro organisms are highly pH sensitive. They cannot work at such a low pH. So it also causes problem in the successful operation of the ETP.

Problem no.3

Falling of leaves in the tube settler

The tube settler is not properly covered so the leaves of the trees, bird's excreta, are falling down in the tube settler, due to which the treated water is again contaminated and the BOD of the treated water is again increased. Thus often present problems in successful operation of ETP.

5.9 Technologies applied for the Solution of problem no. 1

5.9.1. Centrifugal machine

A centrifugal machine is used for the separation of the soil from the resin. This centrifugal machine in used near the rest wat no. 8.

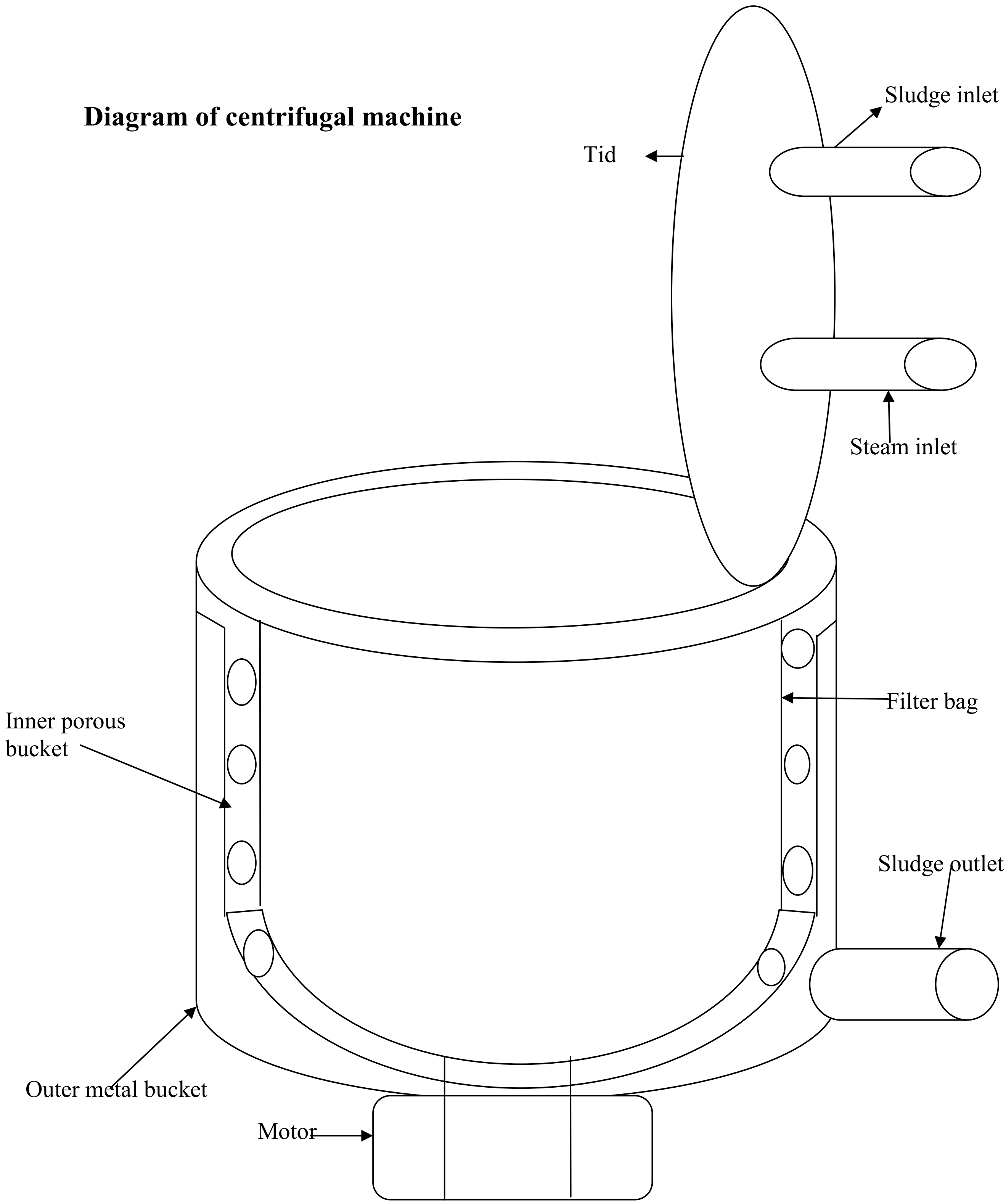
Various part of the centrifugal machine.

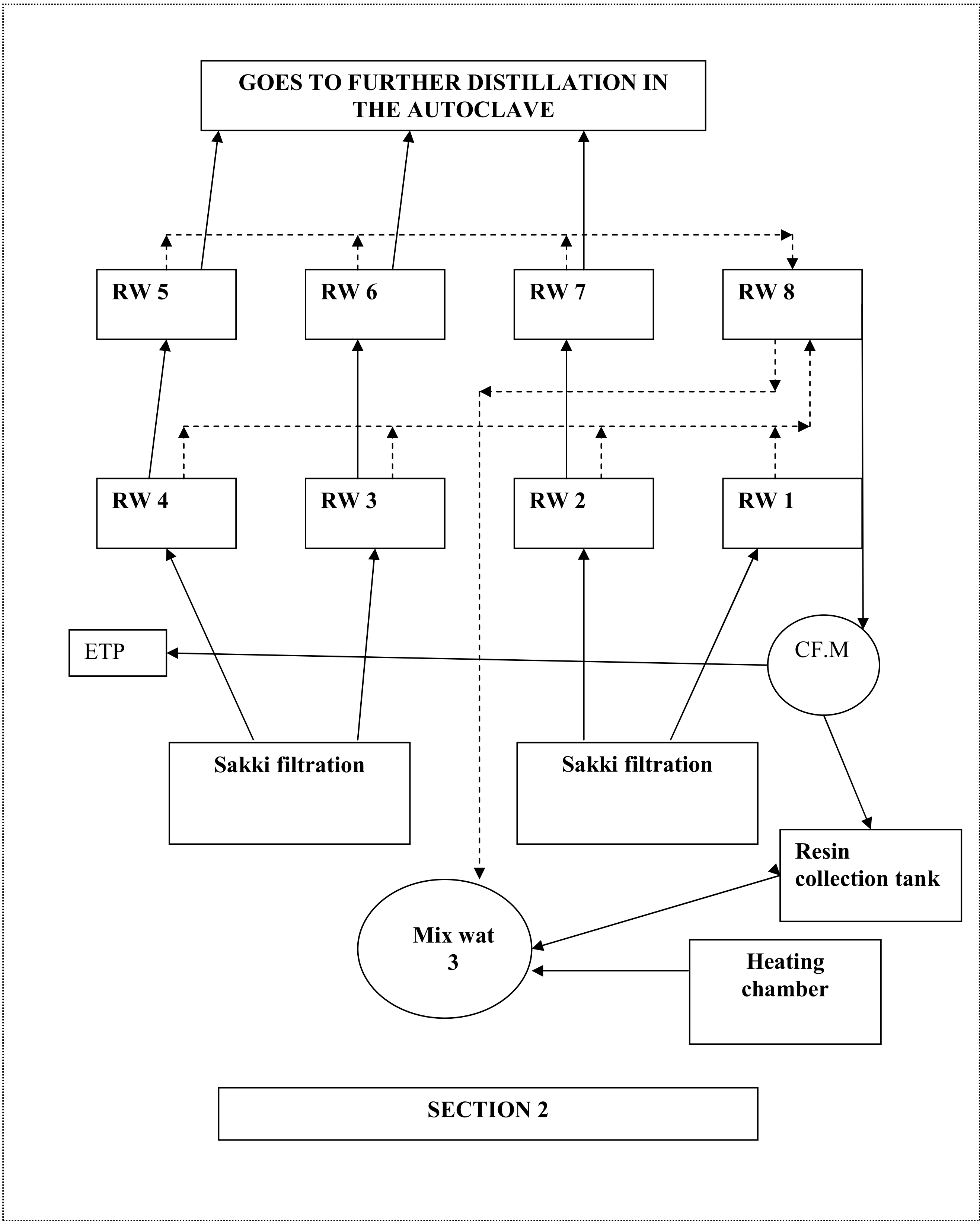
- Outer metal bucket.
- Inner porous metal bucket.
- Filter bag.
- A electric motor of 5hp.
- Steam inlet
- Tid having two opening.
- Sludge inlet.
- Resin out let.

Working of the machine.

The centrifugal machine with operating speed 1000 rpm and having the capacity of filtering 30 liter sludge is installed in Section 2. The inner bucket of the machine is porous. There is a filter bag in the inner bucket. The filter bag is not fixed and can be removed after two or three filtrations. It is fixed with the help of clips. The sludge (resin mix with soil) about 30 liter is filled in the machine. Then steam is directly added in the sludge for increasing the temperature of sludge. The temperature is increased up to 60^0C. The steam is supplied for 3 to 4 minutes only. Due to increase in temperature the sludge become in the liquid form. Then the motor is started for 5 minutes. Due to the centrifugal force the liquefied sludge is filtered, and it comes out through the porous inner bucket and then comes out through the sludge outlet. The soil remains in the filter bag. The filter bag is removed after the 3 or 4 filtration and then the filter bag is washed. Then again it is fixed in the machine and used. One filtration normally takes 6 to 8 minutes, so approximately 200 liters is filtered in one hour. The resin is collected in a tank which is placed near the outlet of the sludge. Due to the addition of the steam some water is also mixed in the sludge, but when the resin is collected in the tank, the water settled down, and the resin remains as a supernatant. So the water is shifted to the ETP and the resin is again shifted to the mix wat. Thus no resin is going to the ETP. Thus the resin which is going as waste is now used.

Diagram of centrifugal machine




GOES TO FURTHER DISTILLATION IN THE AUTOCLAVE
RW 5
RW 6
RW 7
RW 8
RW 4
RW 3
RW 2
RW 1
ETP
CF.M
Sakki filtration
Sakki filtration
Resin collection tank
Mix wat 3
Heating chamber
SECTION 2

Solution of problem no.2

Resin entered in to the aeration tank

The resin which enters into the aeration tank is that resin which is mixed in the soil. So the resin is separated with the help of the centrifugal machine and that resin is again used. So there is no resin remains in the effluent. Only the untreated water goes to the ETP. So there is no problem in the successful operation of the ETP.

Solution of problem no.3

Falling of leaves in the tube settler

The leaves from the trees fell down into the tube settler due to which the BOD of the treated water is increased. For the solving of this problem the tube settler is covered with a mesh. So the leaves cannot enter into the tube settler. The data of the treated effluent is given in the Table 21.

Table 21.Data of Treated water of Rosin and Turpentine oil industry Bilaspur

Parameter	Values
BOD	32 mg/liter
COD	240 mg/liter
TDS	360 mg/liter
TSS	95 mg/liter
TS	455 mg/liter
pH	7.5

CONCLUSION

In this work, complete study of the rosin and turpentine oil has been done. It can be concluded that after certain problems in the successful operation of effluent treatment plant, the effluent is now fully treated and all the hitches have been removed. During project complete knowledge of installation, operation and maintenance has been taken. Before joining this project, the effluent treatment plant was not installed in the industry. It was under construction. Luckily I got an opportunity to work for this challenging job i.e. successful operation of ETP. During the study of the industry, the main problem was the rosin mix with soil, which could not be removed from the effluent. That rosin entered in the oil and grease scrubber tank and settled down in the tank due to gravity. From this tank that rosin entered in the neutralization tank and further entered in the aeration tank. This resin could not decomposed by the micro organisms. It also affected the growth of the biomass, because it is highly acidic. For the successful operation of the ETP it was very necessary to overcome this problem.

Designing and the installation of the centrifugal machine was the only substitute to overcome this problem. This centrifugal machine successfully filtered the resin from the soil and that filtered resin was again used and increase the production of rosin in the industry. This technology helped in the successful operation of the ETP. The knowledge simulated from the project can be used in almost every industry for successful installation, operation and maintenance of ETP.

In overall, the project was the turning point for me, because it really gave me the confidence to work under extremely hard conditions.

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Additional note

Naval Stores Review is published bi-monthly and contains trade news, information and technical papers on all aspects of the pine chemicals industry. It also includes papers from the annual International Naval Stores Conference organized by the Pulp Chemicals Association. The present annual cost of subscription (late 1994) is US$ 80 (six issues and the *International Yearbook*). The address for subscriptions is: Naval Stores Review, Kriedt Enterprises Ltd. 129 S. Cortez Street, New Orleans, LA 70119, USA.The address of the Pulp Chemicals Association is: PO Box 105113, Atlanta, GA 30348, USA.