

**REPORT
ON
ECOLOGICAL & ENVIRONMENTAL FACTORS
IN PAPER INDUSTRY**

VOLUME-V

**STANDARD TESTING PROCEDURES FOR POLLUTION
RELATED ANALYSIS, METHODOLOGIES AND
TERMINOLOGY**

PREPARED

FOR

INDIAN PAPER MANUFACTURER'S ASSOCIATION

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STANDARD TESTING PROCEDURES, METHODOLOGY AND TERMINOLOGY.

I. STANDARD TESTING PROCEDURES

An effort has been made to present methods that apply generally. Where alternative methods are necessary for samples of different composition, the basis for selecting the most appropriate method is presented as clearly as possible. However, samples with extreme concentrations or otherwise unusual composition may present difficulties that preclude the direct use of these methods. Hence, some modification of a procedure may be necessary in specific instances. Whenever a procedure is modified, the analyst should state plainly the nature of modification in the report of results.

1. CHEMICAL OXYGEN DEMAND:

Significance

The chemical oxygen demand (COD) is used as measure of the oxygen equivalent of the organic matter content of a sample that is susceptible to oxidation by a strong chemical oxidant. For sample from a specific source, COD can be related empirically to BOD, organic carbon, or organic matter. The test is useful for monitoring and control after correlation has been established. The dichromate reflux method is preferred over procedure using other oxidants because of superior oxidising ability, applicability to a wide variety of samples and ease of manipulation. Oxidation of most organic compounds is 95 to 100% of the theoretical value. Pyridine and related compounds resist oxidation and volatile organic compounds are oxidized only to the extent that they remain in contact with the oxidant. Ammonia present either in the waste or liberated from nitrogen containing organic matter, is not oxidized in the absence of significant concentration of free chloride ions.

1.0 Selection of Method:

The open reflux method is suitable for a wide range of waste where a large sample size is preferred. The closed reflux methods are more economical in the use of metallic salt reagents but require homogenization of samples containing suspended solids to obtain reproducible results. Ampules and culture tubes with premeasured reagents are available commercially.

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1.1. Principle:

Most types of organic matter are oxidized by boiling mixture of chromic and sulfuric acid. A sample is refluxed in strongly acid solution with a known volume of potassium dichromate ($K_2Cr_2O_7$) is titrated with ferrous ammonium sulfate to determine the amount of ($K_2Cr_2O_7$). Consumed and the oxidizable organic matter is calculated in terms of oxygen demand. Keep ratings of reagents weights volumes other than 50 ml are used. The standard 2-hr. reflux time may be reduced, it has been shown that a shorter period yield the same results.

1.2 Interference and Limitation:

Volatile straight chain aliphatic compounds are not oxidized to any appreciable extent. This failure occurs partly because volatile organics are present in the vapour phase and do not come in contact with the oxidized liquid. Straight chain aliphatic compounds are oxidized more effectively where silver sulfate (Ag_2SO_4) is added as a catalyst. However, Ag_2SO_4 reacts with chloride, bromide, and iodide to produce precipitates that are oxidized only partially. The difficulties caused by the presence of the halides can be overcome largely, though not completely, by complexing with mercuric sulfate ($HgSO_4$) before the refluxing procedure. Do not use the test for samples containing more than 2000 mg Cl-/L. Techniques designed to measures COD in saline waters are available. Nitrite (NO_2^-) exerts a COD of 1.1 mg O₂/mg NO_2^- -N.

Because concentration of NO_2^- in water rarely exceed 1 or 2 mg NO_2^- - N/L, the interference is considered insignificant and usually ignored. To eliminate a significant interference due to NO_2^- add 10 mg sulfamic acid for each mg NO_2^- - N present in the sample volume used, add the same amount of sulfamic acid to the reflux vessel containing the distilled water blank.

Reduced inorganic species such as ferrous iron, sulfide, manganese, magnesium, etc, are oxidized qualitatively under the test conditions. For samples containing significant levels of these species and corrections can be made to the COD value obtained.

1.3 Sampling and Storage:

Preferably collect samples in glass bottles. Test unstable samples without delay. If delay before analysis is unavoidable, preserve sample by acidification to pH <2 using conc. H_2SO_4 . Blend samples containing settleable solid with a homogenizer to permit representative sampling. Make preliminary dilutions for waste containing higher concentration of organic matter.

1.4 Open Reflux Method-COD Analysis:

1.4.1 Reflux apparatus:

Consisting of 500 ml glass flask 24/40 neck and 300 mm jacket Lie-big, West, or equivalent condensor with 24/40 ground glass joint, and a hot plate having sufficient power to reduce at least 1.4 W/cm^2 of heating surface or equivalent.

1.4.2 Reagents:

a. Standard Potassium Dichromate Solution, 0.041M:

Dissolve 12.259 g. ($\text{K}_2\text{Cr}_2\text{O}_7$) primary standard grade, previously dried at 103°C for 2 hour in distilled water and dilute to 1000 ml.

b. Sulfuric acid reagent:

Add Ag_2SO_4 reagent (technical grade, crystals or power) to conc. H_2SO_4 at the rate of 5.5 g Ag_2SO_4 /Kg H_2SO_4 . Let it stand for 1 to 2 days to dissolve Ag_2SO_4 .

c. Ferroin indicator solution:

Dissolve 1.485g. 1,10 – phenanthroline monohydrate and 0.695 $\text{FeSO}_4 \cdot 7\text{H}_2\text{O}$ in distilled water and dilute to 100 ml. This indicator solution may be purchased already prepared.

d. Standard Ferrous Ammonium Sulfate:

Titrant approximate to 0.25 M: Dissolve 98 g. $\text{Fe}(\text{NH}_4)_2(\text{SO}_4)_2 \cdot 6\text{H}_2\text{O}$ in distilled water. Add 20 ml conc. H_2SO_4 cool and dilute to 1000. ml. Standardize this solution daily against standard $\text{K}_2\text{Cr}_2\text{O}_7$ solution as follows.

Dilute 10.0 ml standard $\text{K}_2\text{Cr}_2\text{O}_7$ to about 100 ml add 30 ml conc. H_2SO_4 and cool. Titrate with FAS titrant using 0.10 to 0.15 ml (2 to 3 drops) ferroin indicator.

	Volume 0.0417 M $\text{K}_2\text{Cr}_2\text{O}_7$ solution
	Titrated, ml x 0.25
Molarity of FAS solution	= -----
	Volume of FAS used in titration

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- e. **Mercuric sulfate, HgSO_4 crystals or powder.**
- f. **Sulfamic acid:** Required only if the interference of nitrites is to be eliminated.
- g. **Potassium hydrogen phthalate (KHP) standard:**

Lightly crush and dry potassium hydrogen phthalate to constant weight at 120°C . Dissolve 425 mg in distilled water and dilute to 100 ml. KHP has a theoretical COD of, 1,176 $\mu\text{g O}_2/\text{mg}$ and this solution has theoretical COD of 500 $\mu\text{g O}_2/\text{mg}$. This solution is stable when refrigerated up to 3 months in the absence of visible biological growth.

1.5 Procedure:

- ❖ Place 50.0 ml sample (for samples with COD 900 mg O_2/L) use smaller sample portion (in case of high COD values) diluted to 50.0 ml in a 500 ml refluxing flask. Add 1 g HgSO_4 , several glass beads, and very slowly add 5.0 ml sulfuric acid reagent with mixing to dissolve HgSO_4 . Cool while mixing to avoid possible loss of volatile materials. Add 25.0 ml 0.0417 M $\text{K}_2\text{Cr}_2\text{O}_7$ solution and mix. Attach flask to condensor and turn on cooling water. Add remaining sulfuric acid reagent (70 ml) through open end of condensor. Continue swirling and mixing while adding the sulfuric acid reagent.

Caution: Mix mixture thoroughly before applying heat to prevent local heating of flask bottom and a possible blowout of flask contents. Cover open end of condensor with a small beaker to prevent foreign material from entering refluxing mixture and reflux for 2 h. Cool and wash down condensor with distilled water. Disconnect reflux condenser and dilute mixtures to about twice its volume with distilled water. Cool to room temperature and titrate excess $\text{K}_2\text{Cr}_2\text{O}_7$ with FAS using 0.10 to 0.15 ml (2 to 3 drops) ferroin indicator. Although the quantity of ferroin indicator is not critical use the same volume for all titrations. Take as the end point of the titration the first sharp colour change from blue green to reddish brown.

❖ Determination of Standard Solution :

Evaluate the technique and quality of reagents by conducting the test on a standard potassium hydrogen phthalate solution.

1.6 Calculation:

$$(A-B) \times M \times 8000$$

COD as mg O₂/L = -----
ml sample

Where A = ml FAS used for blank., B= ml FAS used for sample and M = molarity of FAS.

1.7 Precision and Accuracy:

A set of synthetic sample containing potassium hydrogen phthalate and NaCl was tested by 74 laboratories. At a COD of 200 mg O₂/L, in the absence of chloride, the standard deviation was ± 13 mg/l (coefficient of variation 6.5%). At COD of 160 mg O₂/L and 100 mg Cl⁻/L, the standard deviation was ± 14 mg/l (Coefficient of variation, 10.8%).

2. BIOCHEMICAL OXYGEN DEMAND (BOD):

1.0. Principle:

Biochemical Oxygen Demand is the measure of degradable organic material present in a water sample and can be defined as the amount of oxygen required by the micro-organisms in stabilising the biologically degradable organic matter under aerobic conditions.

1.1. Apparatus:

- 1) BOD bottles
- 2) BOD incubator

1.2 Reagents:

1. Phosphate buffer:
Dissolve 8.5 gm KH₂PO₄, 21.75 g. K₂HPO₄ 33.4 g. Na₂HPO₄, 7H₂O and 1.7 g. NH₄Cl in distilled water and dilute to one litre. pH should be 7.2
2. Magnesium sulphate solution:
Dissolve 22.5 g. MgSO₄ 7H₂O in distilled water and dilute to one litre.
3. Calcium chloride solution:
Dissolve 27.5 g. of CaCl₂, in distilled water and dilute to one litre.
4. Ferric chloride solution:
Dissolve 0.25 g. of FeCl₃.6H₂O in distilled water and dilute to one litre.
5. Manganous sulphate solution:

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Dissolve 480 g. of $\text{MnSO}_4 \cdot 4\text{H}_2\text{O}$ or 400 g. of $\text{MnSO}_4 \cdot 2\text{H}_2\text{O}$ or 364 g. of $\text{MnSO}_4 \cdot \text{H}_2\text{O}$ in distilled water and dilute to one litre.

6. Alkali Azide reagent:

Dissolve 500 g. NaOH (or 700 g. KOH) and 135 g. NaI (Or 150 g. KI) in distilled water and dilute to one litre. Add 10 g. NaN_3 dissolved in 40 ml. distilled water. Potassium and Sodium salts may be used interchangeably. This reagent should not give colour with starch solution when diluted and acidified.

7. 0.025 N Sodium thiosulphate solution:

Dissolve 6.2050 g. $\text{Na}_2\text{S}_2\text{O}_3 \cdot 5\text{H}_2\text{O}$ in distilled water. Add 0.4 g. solid NaOH and dilute to 1000 ml.

8. Starch:

2 g. lab grade soluble starch and 0.2 g. salicylic acid in 100 ml hot. distilled water.

1.3 Procedure:

- ❖ Prepare dilution water in a glass container by bubbling compressed air in distilled water for about 30 minutes.
- ❖ Add 1 ml. each of phosphate buffer, magnesium sulphate, calcium chloride and ferric chloride solution for each litre of dilution water and mix thoroughly.
- ❖ Adjust pH of dilution water to 7.0 by using NaOH or HCl.
- ❖ Add 1 ml of seed for each litre of dilution water.
- ❖ Take suitable portion of sample in one litre volumetric flask and dilute to one litre with dilution water, mix thoroughly.
- ❖ Fill to BOD bottles (300 ml. each) by above solution.
- ❖ Keep one bottle for five days in incubator at 20°C temp and determine its D.O after five days.
- ❖ Determine the D.O content in another bottle immediately.

1.3.1 Determination of dissolved oxygen:

- Add 2-ml MnSO_4 solution and 2 ml of Alkali Azide solution to the sample collected in 300 ml BOD bottle.
- Mix the solution by inverting bottle few times & allow to settle the precipitate.

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- Then add 2 ml. Conc. H_2SO_4 to dissolve precipitate re-stopper the bottle and mix by inverting bottle few times.
- Titrate 203 ml. of above solution with 0.025 N $\text{Na}_2\text{S}_2\text{O}_3$ using starch indicator.
- Similarly for blank, take 2 bottles for dilution water. Determine D.O. content of one bottle immediately and determine D.O. content of another bottle after five days incubation. (at 20°C temp.).

1.4. Calculations:

$$\text{BOD mg/litre} = \frac{(\text{D}_1 - \text{D}_5) - (\text{B}_1 - \text{B}_5)}{\% \text{ of sample.}} \times 100$$

Where:

D_1	=	ml of 0.025 N $\text{Na}_2\text{S}_2\text{O}_3$ consumed by sample.
D_5	=	0.025 N $\text{Na}_2\text{S}_2\text{O}_3$ consumed after incubation of Sample for 5 days
B_1	=	ml. of 0.025 N $\text{Na}_2\text{S}_2\text{O}_3$ consumed by blank.
B_5	=	ml of 0.025 n $\text{Na}_2\text{S}_2\text{O}_3$ consumed after incubation of blank for 5 days

3. TOTAL SUSPENDED SOLIDS:

1.0 Principle:

A well-mixed sample is filtered through a weighed standard glass-fiber filter and the residue retained on the filter is dried to a constant weight at 103 to 105°C . The increase in weight of the filter represents the total suspended solids. If the suspended material clogs the filter and prolongs filtration, the difference between the total solids and the total dissolved solids may provide an estimate of the total suspended solids.

1.1 Interferences:

Exclude large floating particles or submerged agglomerates of non-homogenous materials from the sample if it is determined that their inclusion is not desired in the final result. Because excessive residue on the filter may form a water-entrapping crust, limit the sample size to that yielding no more than 200 mg residue. For samples high in dissolved solids thoroughly wash

the filter to ensure removal of the dissolved material. Prolonged filtration time resulting from filter clogging may produce high results owing to excessive solids capture on the clogged filter.

1.2. Apparatus:

- a. Glass-fiber filter without organic binder.
- b. Filtration apparatus: One of the following, suitable for filter disk selected:
 1. Membrane filter funnel.
 2. Gooch crucible, 25 ml to 40 ml capacity, with Gooch crucible adapter.
 3. Filtration apparatus with reservoir and coarse (40- 60 μ m) fritted disk as filter support.
- c. Suction flask, of sufficient capacity for sample size selected.
- d. Desiccator, provided with a desiccant containing a color indicator of moisture concentration.
- e. Drying oven, for operation at 103 to 105°C.
- f. Analytical balance, capable of weighing to 0.1 mg.

1.3. Procedure:

❖ **Preparation of glass-fiber filter disk:**

Insert disk with wrinkled side up in filtration apparatus. Apply vacuum and wash disk with three successive 20 ml portions of distilled water. Continue suction to remove all traces of water, and discard washings. Remove filter from filtration apparatus and transfer to an aluminum or stainless steel planchet as a support. Alternatively remove crucible and filter combination if a Gooch crucible is used. Dry in an oven at 103 to 105°C for 1 h. If volatile solids are to be measured, ignite at 550 $\pm$ 50°C for 15 min in a muffle furnace. Cool in desiccator to balance temperature and weigh. Repeat cycle of drying or igniting, cooling, desiccating and weighing until a constant weight is obtained or until weight loss is less than 0.5 mg. Between successive weighings. Store in desiccator until needed. Weigh immediately before use.

❖ **Sample analysis:**

Assemble filtering apparatus and filter and begin suction. Wet filter with a small volume of distilled water to seat it. Wash with three successive 10 ml volumes of distilled water, allowing complete drainage between washings & continue suction for about three minute after filtration is complete. Carefully remove filter from filtration apparatus and transfer to an aluminium or stainless steel planchet as a support. Alternatively, remove the crucible and

filter combination from the crucible adapter if a gooch crucible is used. Dry for at least 1 hr. at 103 to 105 in an oven, cool in a desiccator to balance temperature & weigh.. Repeat the cycle of drying, cooling, desiccating and weighing until a constant weight is obtained or until the weight loss is less than 4% of the previous weight or 0.5 mg whichever is less.

Calculation :

mg total suspended solids/ L

$$= \frac{(A - B) * 1000}{\text{Sample volume, mL}}$$

Where

A = Weight of filter + dried residue, mg, and
B = Weight of filter, mg.

4. COLOR:

The Platinum-Cobalt method of measuring color is the standard method, the unit of color being that produced by 1 mg Platinum/ltr. in the form of chloro-platinate ion.

1.1. Applications:

The Platinum-Cobalt method is useful for measuring color of the samples in which color is due to naturally occurring materials like; lignin.

1.2 Preparation of Standards:

In absence of the reliable supply of Potassium chloro platinate, chloro platinate acid prepared from pure metallic Platinum can be used.

- ❖ Potassium Chloro Platinate Standards: Dissolve 1.246 g Potassium chloride ($\text{CoCl}_2 \cdot 6 \text{H}_2\text{O}$) equivalent to 250 mg. metallic Co in distilled water with 100 ml conc. HCl and diluted to 1000 ml. with distilled water. This Stock Standard has a color of 500 units.
- ❖ Standard Using Metallic Platinum: If K_2PtCl_6 is not available, dissolve 500 mg pure metallic Pt. In aquaregia with heating. Remove HNO_3 by repeated evaporation with fresh portions of conc. HCl. Dissolve this product along with 1 g. crystallized $\text{CoCl}_2 \cdot 6 \text{H}_2\text{O}$ as directed above. This Standard has a color units of 500.

Prepare Standards having colors in the range of 5-70, by diluting 0.5, 1.0, 2.0, 2.5, 3.0, 3.5, 4.0 4.5. ---6.0 & 7.0 ml. Stock color standards to a final volume of 50 ml. And measure at 465 nm.

Report Sample pH. In Pulp & Paper Mill effluents color measurement is carried at a pH of 7.6 at 25°C.

1.3 Calculations:

$$\text{Color, PCU} = \frac{\text{Sample absorbance at 465} \times \text{dilution} \times \text{std. color values}}{\text{Absorbance of std. sample at 465 nm.}}$$

5. BIO-ANALYSIS OF SEED SLUDGE:

Total Suspended Solids (TSS) & Volatile Suspended Solids (VSS):

1.0 Procedure:

- ❖ Measure sample and record the weight.
- ❖ Centrifuge the sample and record the weight of the wet sludge after the supernatant is discarded.
- ❖ Dry (all) the wet sludge in a ceramic crucible at 105°C for 1 day and record the weight of the dry sludge.
- ❖ Place the crucible over a gas burner and burn most of the organic matter to charcoal.
- ❖ Place the crucible in the muffle furnace at 600°C for 20 minutes or more to get stable weight, cool in a desiccator and record the weight of the ash.

1.1 Calculation:

The TSS & VSS is calculated as follows:

$$\text{TSS, g/l} = \frac{\text{dry weight} \times 1000}{\text{sample weight}}$$

$$\text{VSS g./l} = \frac{[\{\text{dry weight} - \text{ash weight}\} / (\text{sample weight})] \times 100}{}$$

6. METHANOGENIC SLUDGE ACTIVITY:

1.0 Purpose:

This assay is performed to determine the specific methanogenic activity of anaerobic sludge VSS. It measures the potential available in anaerobic sludge to convert the organic matter into methane gas. The methanogenic activity of sludge is dependent on many factors. If we want to measure the real potential activity of the sludge then it is necessary to ensure that ideal conditions are provided.

1.2 Factors Affecting Methanogenic Sludge Activity:

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1.2.1 Temperature:

The temperature plays an important role on the activity of sludge, normally 30°C is recommended to measure the activity of sludge. The activity of sludge can be measured at same temperature of reactor operation.

1.2.2 Concentration of Substrate & Sludge:

The concentration of substrate in the micro environment of the methanogenic bacteria is critical. Although bacteria has a high substrate affinity. The ranges of concentration of substrate & sludge are given below:

- Recommended sludge and substrate concentration for the Methanogenic activity assay

Experimental System	Sludge gm VSS/L	VFA or Sucrose gm COD/L
Stirred	2.0 – 5.0	2.0 – 4.0
Unstirred	1.0 – 1.5	3.5 – 4.5

1.2.3 Activity Period:

Activity period is the time period when the methane gas production rate is the highest during the experiment. During this time period at least 50% substrate must be converted into methane gas and it should not be a small period.

1.3 Procedure:

- ❖ Add water to one half the liquid volume of the serum bottle, charge the required amount of VFA or sucrose solution along with the nutrient. Now finally add the desired quantity of sludge and make up the effective volume with water. (This volume should equal to 90% of the bottle volume) and now blow N₂ through the liquid for 3 minutes and then put it on stirring system at constant temperature and record the gas production daily until about 80% of the substrate is utilized.

1.4 Calculation:

From the average slope during the activity period, the methanogenic activity of sludge can be calculated as follows:

$$\begin{aligned} \text{Activity} &= \frac{\text{Max. CH}_4 \text{ production (l/d)}}{\text{amount of sludge, g. VSS}} = \frac{X/Y \times 242.6}{\text{amount of sludge}} \\ \text{(g COD red./g VSS. D)} & \\ \frac{X}{Y} &= \text{Max. methane production rate i.e. when the curve is steepest.} \end{aligned}$$

7. SLUDGE PROFILE:

1.0 Purpose:

The amount of sludge in the reactor can be determined by a sludge profile. By knowing the quantity of sludge, it is possible to predict the maximum organic loading, if we also know the methanogenic activity of the sludge.

One should realise that the sludge content and activity are subject to many changes during reactor operation. After stable operation is achieved, the activity will remain constant but the sludge content will increase steadily.

1.1 Sampling:

The most critical point in determining the amount of sludge in a reactor is the sampling. When you open the sampling valve, make sure that you let the volume in the pipes washout first before collecting the sample. The sample should be weighed instead of direct volume measurement (assume 1 g/ml).

1.2 Quantity of VSS in the reactor:

The VSS concentration should be plotted on graph paper versus the height (sludge profile) of the sampling points. The sampling point height of the reactor can be converted into the volume of the reactor. The area under the plotted curve represents the total sludge content of the reactor. The total sludge content of the reactor divided by the total volume of the reactor is the average sludge concentration of the reactor.

II. METHODOLOGIES

1. EIA AND ITS ROLE FOR SUSTAINABLE DEVELOPMENT

Plans, disaster management plan, forest management plan, green belt design. Rapid EIA involves assessment based on one season (3 months) while comprehensive EIA involves assessment based on three seasons (9 months) monitoring for base line data collection.

1.0 EIA PARAMETERS AND METHODOLOGY:

Some of the basic steps in EIA involves base line study, scoping or impact identification, impact measurement, impact analysis, mitigating measures, monitoring of the scheme, disaster management plan. The various methods used in EIA are Adhoc Method; Overlays; Checklists; Matrix; Network; Integrated method-combination of matrices, network, analysis models and computer aided systematic approach. Some of the salient features of these methods is given in Table-1.

TABLE-1

SUMMARY OF THE ENVIRONMENTAL IMPACT ASSESSMENT METHODOLOGY

Method	Description
Ad hoc method	First step involves consideration of environmental area and identification of the nature of the impact upon it. Such as no effect, problematic, short-or long term and reversible or irreversible.
Overlay Method	This method relies on a set of maps of a project areas environmental characteristics (physical, social, ecological, aesthetic etc.)
Impact Checklists Method	This involves combining a list of potential impact areas that need to be considered in the environmental impact assessment process with an assessment of the individual impacts.
Leopold Matrix Method	This basically incorporate a list of project activities or actions with a checklist of environmental conditions or characteristics that might be affected. Combining these lists as horizontal and vertical axes for a matrix allows as horizontal and vertical axes for matrix allows the

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	identification of cause-effect relationships between specific activities and impacts.
Battelle Environmental Evaluation system	In this method human concern are separated into four main categories-ecology, physical ,chemical , ion system aestheticsm human interest/social and each categories contains a number of components that have been selected specifically. For each component index of environmental quality is developed, normalised to a scale ranging from 0 to 1, using a value function method. Each impact indicator is then given as the difference in environmental quality between the stages with and without action.
Net Work Method	This start with a list of project activities or action and then generate cause-condition-effect new-works (i.e. chains of events).
Integrated Method	This uses a combination of matrices, net work, analytical models and a computer aided systematic approach.
Probabilistic Method	This method uses mathematical models of the environmental phenomenon. Numerical odds are assigned to every possible out come or combination of out comes. On the basis of such assigned odds prediction statement are made about the future behaviour of the phenomenon studies, even.
Habitate evaluation System (HES)	HES system is applicable to water resources and involves six basic steps (i) Defining habital type or extent (ii) Deriving habitual quality index scores (iii) Deriving habitual unit values (iv) Projecting HUVS for future with and without project conditions (v) Using HUVS to asses impact of project alternatives (vi) Determining mitigationonn requirement.

2. CLEANER PRODUCTION METHODOLOGY:

The tools used for doing cleaner production is “**Cleaner Production Audit (C.P. Audit)**” or a “**Waste Assessment**”. This involves observing, measuring, recording data and collecting and analyzing samples of waste. Material and energy balances for the process must be made. To be effective this must be done methodically and thoroughly with full management support. A typical waste assessment includes the following six steps:

- (i) Put together a team responsible for the task and make a list of the process steps. Identify obviously important or waste full process steps for focus of assessment.

- (ii) Analyze the process steps in further detail with the aid of flow charts and material balances. Assign costs to the waste streams and identify the causes of the waste generation.
- (iii) Suggest solutions to minimize or eliminate waste streams and wasteful process steps.
- (iv) Analyze the proposed solution from technical, economic and environmental angles to decide which solutions are feasible and most desirable to implement.
- (v) Implement the selected solution and monitor and evaluate results.
- (vi) Start over again. The assessment needs to be repeated periodically to keep the production optimized.

1.0 CLEANER PRODUCTION INDICATORS:

In the context of pulp and paper industry, the following cleaner production indicators may be taken as examples:

1.1 Process technology:

This normally puts an upper limit on possible technical performance of a mill. Best management can help to achieve the limit performance. The differences between actual performance with the best is the driving force for improvement

1.2 Specific Water Consumption:

Pulp and Paper Industry is highly water intensive Reduction in fresh water consumption should be one of the principal objectives of cleaner production and hence this is an important indicator.

1.3 System Closure:

This is another important parameter related to inputs including water consumption. System closure can be said to be the ratio of chemicals lost or water discharged to the amount of chemicals or water recycled back into the system. In practical terms, it is easier to define the system closure as the ratio of the amount of chemicals lost or water discharged to the total amount of chemicals water used. This could be for caustic soda or lime or water and any other materials.

1.4 Specific Energy Consumption:

This can be defined separately for steam and power. Purchased electrical energy can also be considered as a parameter.

1.5 Specific Pollution Load:

Pollution load measured as Kg/ton of paper or pulp can provide a good cleaner production indicator. For liquid effluents these can be COD;TS;TSS;AOX; Residual Cl_2 and volume of discharge.

1.6 Process Efficiency:

In pulp and Paper Industry there are several parameters that give an indication of the efficiency at each stage of the process. The important parameters include fiber loss; pulp mill yield; washing efficiency; recovery efficiency and boiler efficiency.

1.7 Aesthetics:

This cleaner production indicator can often be the most dramatic and provide extra movement for cleaner production programs. The indicator is subjective but none the less useful. Aesthetics can be graded on 1 to 10 scale based on set of guidelines.

2.0 Cleaner Production Approaches in Pulp and Paper Industry:

Cleaner production basically requires the following:

- ❖ Proper selection and layout of equipment
- ❖ Proper operation of equipment
- ❖ Proper house keeping.

Pulp and paper manufacturing is a complex process involving several unit operations and processes. The main sections are:

- ❖ Raw Material Preparation and Handling;
- ❖ Cooking;
- ❖ Washing and Screening;
- ❖ Bleaching;

- ❖ Chemical Recovery;
- ❖ Stock Preparation and Papermaking;
- ❖ Utilities (Steam, Electricity, Air, Water and Vacuum);
- ❖ Effluent Treatment.

3. BENCHMARKING THE PERFORMANCE OF THE MILL:

As an individual effort of the mill in improving its environmental situation; the industry should first benchmark its performance and improve it. To meet the competition from the International market, it has to adopt the cleaner technology which minimises, the pollution and improves the product quality.

The benchmarking means comparison of different features of an individual mill with other mills in its time of activity. Originally concerned more with quality and productivity issues, benchmarking has more recently been used to help determine the environmental performance of mills.

Benchmarking is a useful concept to mills that are serious about improving its environmental performances. First bench marking can help a mill determine where, opportunities exist, so that it can target its efforts selectivity. It helps the mill to compare certain aspects of its operations with mills using similar raw materials, equipment etc. A mill may compare its:

- raw material consumption
- chemical consumption & recovery
- energy requirements
- final effluent discharge volume, etc. with other units based on similar raw material and their determine its performance, indicating the specific area which requires on further examination and set targets in India or abroad. Table – 1 shows the performance of similar paper mills in India having the similar raw material consumption pattern, but having variations in consumption & outputs.

TABLE – 1

THE PERFORMANCE OF FEW INDIAN LARGE PULP AND PAPER MILLS

Paper Mills	1	2	3	4	5	6
1. Installed Capacity, (TPD)	165	140	230	190	180	260
2. Raw Material	B/H.W.	B/H.W.	B/H.W. Waste Paper	B/H.W. Rags	B/H.W. Waste Paper	B/W. Waste paper
3. Mixed yield %	39	40	42	44	44	46
4. Chemical Recovery, %	82	83	90	86	91	95
5. Power Consumption (KWH/T)	1450	1370	1240	1410	1310	1250
6. Steam Consumption (T/T)	12	11	10	10.5	10	9.5
7. Chlorine Consumption %	12	10	10.5	11	9.5	9
8. Waste Water generation(M³/T)	210	230	200	190	180	170
9. Pollution load (Kg/T)						
Suspended Solids	134	131	102	151	96	88
BOD	52	51	35	53	48	35
COD	158	217	206	213	158	155

□ **Benchmarking can be either:**

- **Internal benchmarking:**

Where a mill measures its performance with the past results and sets new targets. Table – 2 shows the Internal targets of a pulp “Paper Mill”.

- **External Benchmarking:**

The external benchmarking methodology helps the mill to compare certain aspects of its operation like – specific water consumption, system closure, energy consumption, pollution load, process technology & its efficiency with other mills. Generally, in case of external benchmarking targets are set

against a mill running under ideal condition. so that the effluent & air quality of satisfactory discharge limits is attained.

TABLE – 2

INTERNAL TARGETS OF A PULP AND PAPER MILLS

Particulars	Last Year	1 st Quarter	2 nd Quarter	3 rd Quarter	Target
1. Pulp Yield, %					
Bamboo	45	45	48	47	49
HardWood	40	41	44	43	45
2. Chemical Recovery, %	92	94	94	95	97
3. Steam coal Ratio	4	4	4	4.1	4.1
4. Power/T Machine Machine Prod.	220	210	210	200	190
5. Total Chlorine, %	9	8.9	8.5	8	7.5
6. Water Consumption (M ³ /T)	200	188	191	178	175
7. Stack Emissions SPM (mg/Nm ³)	150	141	126	120	110
8. Waste Water load					
S.S. (Kg/t)	106	98	78	61	53
BOD(Kg/t)	53	50	48	30	22
COD(Kg/t)	150	139	126	120	105

Process Technology, its efficiency in relation to Benchmarking:

Although, the process technology adopted parts a limit on the possible technological performance of the mill. For instances, a pulp mill having CEHH bleaching can get a lowest TOCl discharges level of 2.0 Kg/t of pulp. Any lower discharge level will require a different bleaching sequence.

However, there are several parameters that give an indication of the efficiency of the different processing stages in a pulp & paper mill. These parameters show the overall losses in the system on sub-system and thus provide an estimate for potential of improvement. One of the important example can be quoted from small/medium agora based mills without chemical recovery system.

Some of the mills notwithstanding the fuel value of lignin still continue to produce pulp of higher kappa number to compromise in the cost of cooking

chemicals and they have preferential practice to remove the lignin in the bleaching process as the cost of bleaching chemicals are lower than that of cooking chemicals. However, this process results in higher discharge of halogenated organic compounds, higher BOD & COD as shown in following Table – 3.

TABLE - 3

Cooking Chemical Charge %	Cooking Chemical kg/t pulp as NaOH	Kappa No.	Bleach Chemical Elemental (CEH)	BOD	COD	AOX	Cost of Chemicals
8	145	30	120	50	125	19	-
12	218	20	80	19	40	9	-

Although, apparently it seems that economic advantages are gained in terms of cost of bleached pulp. But, while considering the entire economics incorporating the effluent treatment costs, the economics & environmental advantages fall in favor of low kappa pulping.

Thus there are some of the benchmarking efforts to compare the working of a mill in the pretext of its basic consumption figures, process optimization & its efficiency etc.

Bench marking is a useful concept to mills that are serious about improving its environmental performances. First bench marking can help a mill determine where, opportunities exist so that it can target its efforts selectively. It helps the mill to compare certain aspects of its operations with mills using similar raw materials, equipment etc. A mill may determine that its specific water consumption is much greater than the industry average, indicating that this area is worth examination and set targets.

III. TERMINOLOGY

Acute Toxicity:

Poisonous effect produced by an effluent with a short period of time (usually up to 96 hours), possibly causing severe biological damage to the receiving water.

Adsorbable Organic Halogen (Aox):

Measure of the amount of the organically combined halides (i.e. fluoride, chloride, bromide & iodide) in a waste water sample. This test (involving the adsorption of chlorinated organics onto activated carbon) is tending to displace the TOCl test as a regulatory guideline.

Ambient Air:

Surrounding Environmental Air.

Aerobic:

Requiring the presence of free molecular oxygen

Anaerobic:

Requiring (or tolerant to) the absence of free molecular oxygen.

Bioaccumulation:

Build up of contaminants in living organisms above a natural background level.

Bioassay:

Employment of living organisms to determine the biological effect of a waste water, chemical agent or condition. Typically, a number of individuals of a sensitive species are placed in water containing varying concentrations of a contaminant for a specified period of time.

Biochemical Oxygen Demand (BOD):

It is empirical standard test used to determine the relative oxygen requirement of waste Waters, effluent & polluted bottles. The test measures the oxygen utilized the during the specified incubation period for the biochemical degradation of organic material (Carbonaceous demand) and the oxygen used to oxidized inorganic material such as sulfides and ferrous ions. It also may measure the oxygen used to oxidized reduced form of nitrogen (nitrogenous demand) unless their oxidation is prevented by an inhibitor.

Biobleaching:

The treatment of pulp to reduce color or to reduce color demand in chemical bleaching, the latter has been referred to as “bleach boosting”.

Bio-Pulping:

Treatment of raw material with a lignin degrading fungus prior to pulping. With mechanical pulping, the fungal pre-treatment can result in significant refiner energy savings, depending on the fungus used. With chemical pulping the fungal treatment reportedly can give chemicals and energy savings, depending on the fungus use.

Biotechnology:

Any technique that uses living organisms (or parts of organisms) to make or modify products, to improve plants & animals or develop microorganisms for specific use.

Chemical Oxygen Demand (COD):

COD is used as a measure of the oxygen equivalent of the organic matter content of a sample that is susceptible to oxidation by a strong chemical oxidant. For samples from a specific source COD can be related empirically to BOD, organic carbon or organic matter.

Condensates:

Steam which has condensed, or turn into liquid.

Color:

Designated as either “True color or Apparent color”. True color is associated only with substances in solution. Apparent color is caused by suspended matter as well as dissolved suspended.

Ecology:

Interrelation ship of living things to one another and to their environment (or the study there of).

Ecological Impact:

Total effect of an environmental change on the ecology of an area.

Electrostatic Precipitator:

An Air pollution control device that removes particulate matter by imparting an electrical charge to particles in a gas stream (e.g. flue gases) for mechanical collection on an electrode.

Environment:

Sum of all external conditions and influences affecting the life and development of an organism.

Environmental Audit:

Thorough examination of a plant's environmental practices to objectively assess compliance with environmental regulatory requirements.

Extended Delignification:

A modification of the kraft pulping process. Instead of putting all the chemicals into the digester at the beginning of the cook, various concentrations of the black liquor are exchanged during the cook. This allows lower target kappa numbers with higher yield & strength than normal kraft pulp. Commercially, extended delignification is called **modified continuous cooking or displacement batch pulping**.

Life Cycle Assessment:

This is a "Cradle to grave" methodology that attempts to measure the resource and environmental impacts of a product over its entire life cycle from raw materials extraction to the used products disposal.

Mercaptans:

Family of compounds that have structures similar to alcohols except that the oxygen is replaced by sulfur. The simplest structure methyl mercaptan (CH_3SH), having the characteristics disagreeable order of rotten cabbage, is a

common odor pollutant in kraft mills. It is a detectable by smell in concentrations as low as one part/billion.

Oxygen Bleaching:

A relatively modern bleaching process for wood & other pulps, involving the use of oxygen in an alkaline medium to reduce lignin & other dark coloured components. This process reduces the overall level of bleaching chemicals and lowers the BOD demand of the effluent

Oxygen Delignification:

The treatment of raw material or pulps with oxygen in an alkaline medium oxidizes degrades, and solubilizes the lignin. It is an established technology as a stage between the pulping digesters and the bleach plant to remove up to half of the residual lignin in the brown stock without unduly damaging the strength properties of the pulp.

Risk Assessment:

This is a methodology which permits assigning magnitudes and probabilities to adverse effects, for defined end points, resulting from the impacts during the life cycle of a products.

Risk Assessment approaches are being applied already at many steps in the flow of materials and in the life cycles of the product. For example, in the evaluation of packaging containing food, in the evaluation of discharges into media in general for both human & ecological wealth. Ecological risk assessment & ecotoxicology are more recent tools still in development because of the larger complexities presented by ecosystems in their pathways from individuals to sps. etc.

Suspended Solids:

The amount of total suspended matter present in one liter of an effluent or waste water sample when filtered through a standard glass fibre filter and dried to a constant weight at 103 to 105°C.

Sustainable Development:

Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs.

The most widely coated definition of sustainability is the one developed by the United Nations world Commission on Environment & Development (BRUNDTLAND Commission 1982).

Sustainable Technologies:

Sustainable technologies or Environmental technologies as defined by the National Science & Technology Council (NSTC) encompass all technologies that is hardware, software, systems & services, that constitute support and advance sustainable development by reducing risk, enhancing cost effectiveness, improving process efficiency, and creating process products or services that are environmentally beneficial or benign.

Toxicity:

Quality or degree of being poisonous or harmful to plant or animal life.