

**SUMMARY REPORT
FOR
LIFE CYCLE ASSESSMENT OF PIPES**

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EXECUTIVE SUMMARY

1.0 Introduction

The life cycle assessment study presented below illustrates the impacts of PVC/HDPE pipes during its life cycle and compares the same with those of its alternatives. This study has been commissioned by the Indian Centre for Plastics in the Environment (ICPE). The study has been conducted following the ISO 14040 standards guidelines for Life Cycle Assessment.

2.0 Goal of the study:

The overall goal of the Life Cycle Assessment (LCA) study is to evaluate the impacts of PVC/HDPE pipes during its life cycle vis-à-vis the competing materials steel and RCC.

3.0 Target Audience

The target audience is the policy makers who are involved in issuing policies related to Plastic Use and Management.

4.0 Scope of the study

The applications considered for the purpose of the, study, alternative materials considered, functional unit and processes/stages excluded from the scope of the study are discussed in the following sections

4.1 Applications considered

The applications considered for the study include

- Water supply
- Sewage
- Storm water supply
- Gas supply

4.2 Alternatives

The alternatives considered for comparison with PVC and HDPE pipes included

- Mild steel Pipes
- RCC Pipes

4.3 Stages of life cycle

The life cycle stages considered for this study include

- Production of raw material
- Production of the pipes
- Transportation of the pipes
- Usage
- Waste management (Reuse/ Recycle/Disposal)

The modes of disposal studied include incineration and landfill.

4.4 *Functional unit of the study*

“The production, use and disposal of Φ mm pipe to transport 10 kl of fluid at x bar pressure over a distance of 1000 metres”.

The diameter of the pipe depends on the application studied.

4.5 *Exclusions*

The life cycle stages, processes and data not included in the study is listed below

- Infrastructural requirements
- Manufacturing of chemicals not forming a part of the final product.
- Transportation of materials by modes other than road.
- Material inputs less than 1% of the total input.
- Economic and socioeconomic parameters.

5.0 **Life Impact Assessment**

The Life Cycle Impact Assessment (LCIA) phase involves the evaluation of potential human health and environmental impacts due to the environmental releases and depletion of resources. LCIA involves the use of science based conversion factors for calculating the impacts that each environmental release has on issues such as smog or global warming. There are various methodologies available for carrying out an LCIA. The criteria for the selection of the impact assessment methodology and a brief discussion on the selected methodology is presented below in the following section.

5.1 *Selection of the assessment method:*

Keeping in view the nature of the study, the following parameters have been decided upon for selection of the impact assessment method:

1. Completeness with respect to impact categories
2. Modeling techniques used
3. Worldwide acceptance
4. Time perspective

Keeping in line with the ISO 14040 standards guidelines, emphasis has been given on methodologies that consider higher number of impact categories. Since the study is related to the comparison of the products for public assertion, assessment methods using state of the art scientific models have been preferred over methods using simpler techniques. Worldwide acceptance and time perspectives have been given a comparatively lower emphasis. Also, an impact assessment method with a balanced time perspective has been preferred for the purpose of the study.

The impact assessment methods were weighted using the above criteria and the results of the same are presented below:

Table 1.1: Decision criteria for selection of LCIA method

Impact Assessment Method	Completeness	Modeling	Acceptance	Time Perspective
Eco Indicator 99 (E)	H	H	L	L
Eco Indicator 99 (H)	H	H	L	M
Eco Indicator 99 (I)	H	H	L	L
EPS	H	H	L	L
CML 2000	N	M	L	L
EDIP	M	H	M	L

(Suitability criteria: H: High, M: Medium, L: Low, N: Not suitable)

It can be observed from **Table 1.1** that the Ecoindicator 99 methodology with an heirarchist time perspective, based on the defined criteria, stands out to be the better option.

5.2 *Eco indicator 99*

The damage categories across which the impacts can be evaluated using Eco Indicator 99 methodology are:

Human health:

The damage category, 'Human health', indicates the adverse impact on human health due to the release of pollutants into the environment.. The impact categories included within this damage category are:

- Carcinogens
- Respirable organics
- Respirable inorganics
- Climate change
- Radiation
- Ozone layer

Ecosystem quality

Ecosystem quality indicates the adverse impact on ecosystem quality due to the release of pollutants into the environment. The impact categories included within Ecosystem quality are:

- Ecotoxicity
- Acidification / Eutrophication
- Land use

Resources:

Resources indicate the adverse impact of consumption of material during the life cycle of the product that lead to depletion of resources. The impact categories included within Resources are:

- Minerals
- Fossil fuels

5.3 Life cycle impact assessment results

The life cycle impact assessment results for the pipes are presented in the **Tables 1.2 and Table 1.3**. **Table 1.2** presents the scores in terms of absolute scores while **Table 1.3** presents the scores for the alternatives relative to PP-HDPE. **Figure 1.1** presents the impact category score while **Figure 1.2** presents the damage category score. Lower the score, superior is the environmental performance of the product.

Keeping in line with the ISO 14040 standards guidelines, weighting sets have not been used and not single scores have been provided

Table 1.2 : Life cycle assessment indicator scores for pipes (Points)

Damage category	RCC	PVC	MS	HDPE
Human Health	55.21	8.89	1136	3.35
Ecosystem Quality	0.63	0.83	0.32	0.32
Resources	70.93	43.02	43.49	28.92

Table 1.3: Life cycle assessment indicator scores for pipes (%)

Damage category	PVC	MS	HDPE	RCC
Human Health	1	1.28	0.376	6.21
Ecosystem Quality	1	0.377	0.39	0.76
Resources	1	1.01	0.67	1.65

Figure 1.1: Life cycle assessment indicator scores for pipes (Impact category)

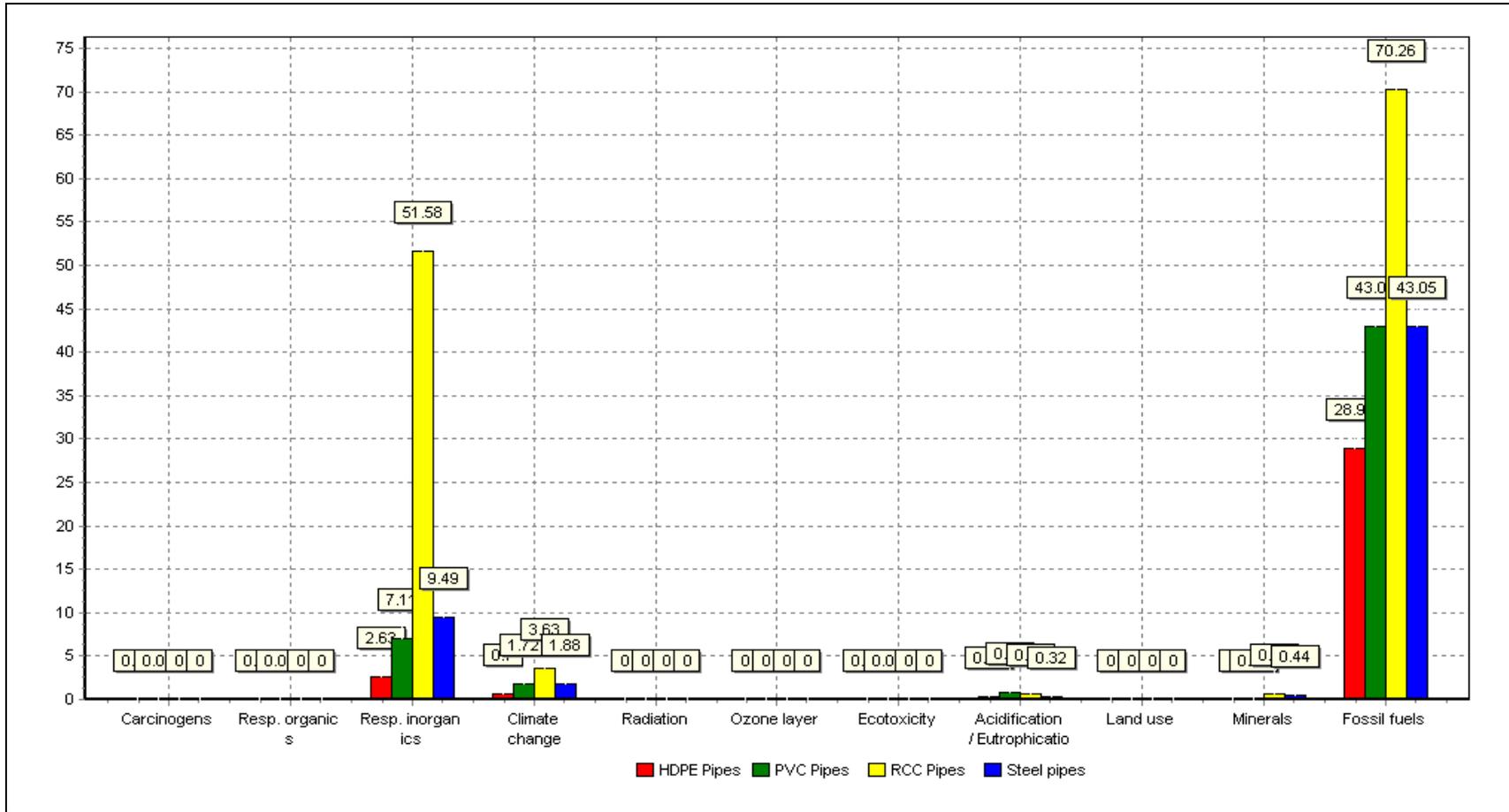
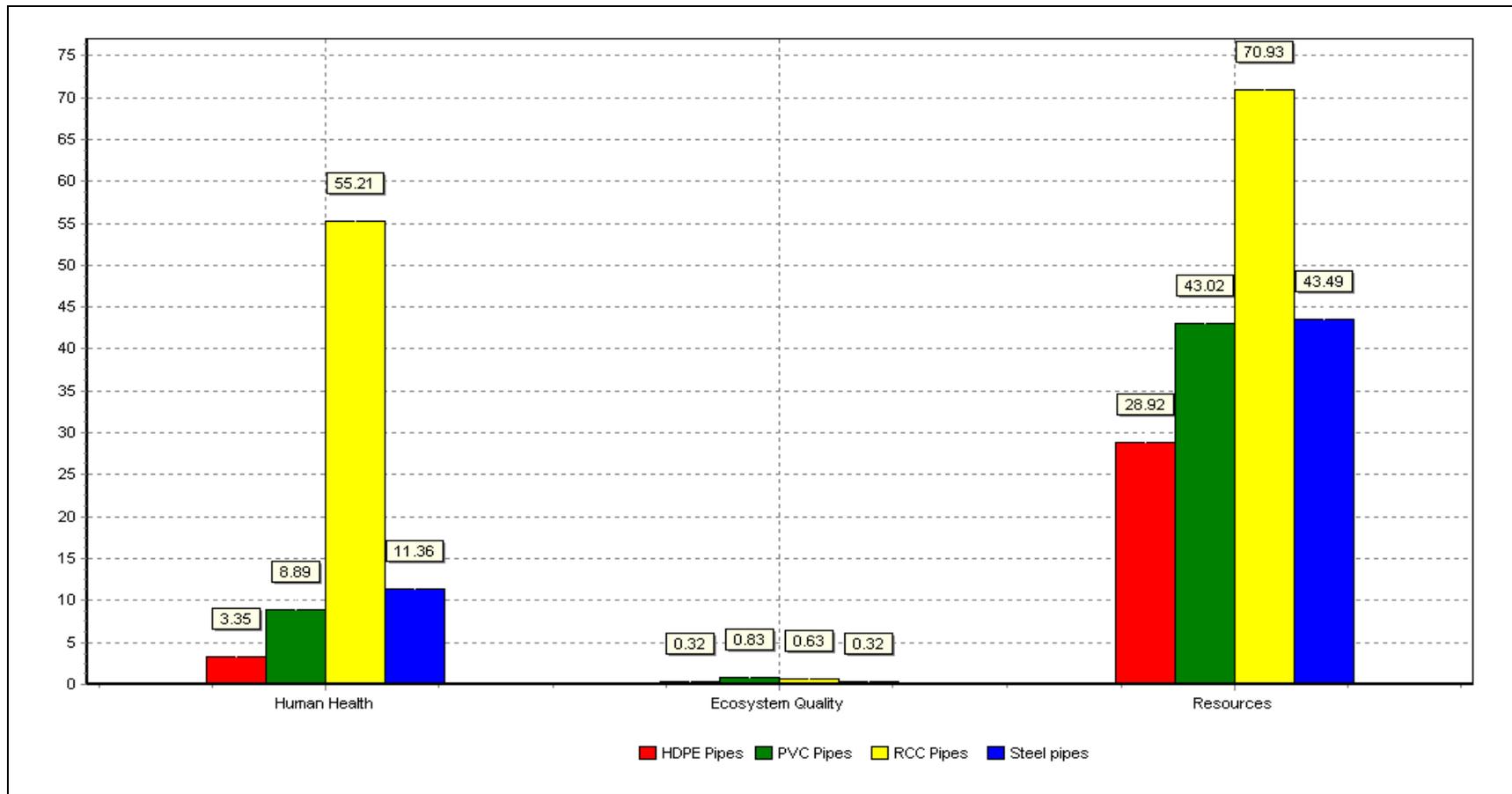


Figure 1.2: Life cycle assessment indicator scores for pipes (Damage category)



6.0 Interpretation of results

Mild Steel Pipes

Mild steel pipes during its life cycle have an impact on eight categories. The impact on Respirable inorganics, Fossil fuels and Climate change is relatively high while the impact on Minerals, Carcinogens and Respirable organics is low.

As compared to HDPE pipes, mild steel pipes have a higher score across all the three damage categories.

Steel manufacturing process is highly resource intensive. Also, iron ore is a non renewable resource. Hence the impact on the damage category resource is high. Emission of sulfur oxides, oxides of nitrogen and particulates into the air environment result in high impact on the impact categories, respiratory organics and acidification/eutrophication.

RCC Pipes

RCC pipes during their life cycle have an impact on eight categories including Respirable organics and inorganics, Acidification/Eutrophication, Climate change, Fossil fuel, Minerals and Land use. The impact on Respirable inorganics and Fossil fuels is relatively higher.

As compared to PVC pipes, RCC pipes have a higher score for Resources and Human health but a lower score for Ecosystem quality. As compared to HDPE pipes, RCC pipes have a higher score across all the three damage categories.

RCC pipes have comparatively higher impact on the damage categories human health and resources. Since the impacts occurring during the steel and cement manufacturing process are high, the total impact across the life cycle is also very high. The life cycle impacts of the RCC pipes also impacts ten categories. The major issues with RCC pipes are the emissions of green house gases, consumption of non renewable resources, and emission of sulfur oxides, oxides of nitrogen and particulates into the air environment.

PVC Pipes:

PVC profiles during its life cycle have an impact on Carcinogens, Respirable organics and inorganics, Climate change, Ecotoxicity and Acidification/Eutrophication. PVC pipes have the highest impact on fossil fuels. Respirable organics and Climate change are the other categories with relatively high impact.

As compared to HDPE pipes, PVC pipes have a higher score for all the three damage categories.

The use of crude oil is a major contributor to the score for PVC pipes. However, on account of its light weight, PVC results in energy saving during the transportation stage. Also, the use of Crude oil as a raw material is a major contributor to the score for Resources. The energy consumption during the life cycle of PVC as compared to its alternatives is relatively lower. It may also be noted that a waste disposal scenario considering the incineration of the pipes has not been considered as it may lead to the release of dioxins. Dioxin is a carcinogenic material and is awarded a relatively high score in methodology used.

HDPE Pipes

HDPE pipes during its life cycle impact Carcinogens, Respirable organics and inorganics, Climate change, Acidification/ Eutrophication and Ecotoxicity. The impact on Fossil fuel, Climate change and Respirable organics is comparatively higher.

HDPE pipes as compared to the other three alternatives studied have a lower score across all the three damage categories.

The parameters that have a major bearing on the scores for HDPE pipes are use of crude oil, air emissions during the manufacturing process. HDPE pipes have a relatively high impact on the damage category resource primarily because of the use of crude oil as a raw material in the manufacturing process. However, the impact on resources category is more due to the use of oil (about 90%) rather than the use of energy during the entire life cycle HDPE. HDPE being light weight and recyclable results in a lower impact across all the three damage categories.

7.0 Limitations

The study is intended to be a comparative study for PVC & HDPE pipes versus the alternatives. Hence, a completeness check has been done for PVC & HDPE pipes. The scores are to be considered in a relative sense and are meant to indicate higher or lower impact.