



## Estimation of Water Losses and Savings at Some Organizations In Visakhapatnam Using Initial Water Balance Studies

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### ABSTRACT

Water auditing is very useful to estimate water losses and savings. Water audit identifies water uses such as sanitation, irrigation, heating and cooling process and maintenance of the distribution system. Unaccountable losses are investigated and areas are identified in which water use efficiency can be improved using alternative technologies or practices. A comprehensive audit can give the utility and detailed profile of the distribution system and water users, allowing appropriate management of water resources and improved reliability. It is an important step towards water conservation and linked with a leak detection plan that can save the utility of a significant amount of fresh water and time. Therefore, water supply balance studies are an important part of water auditing. The water supply balance studies were carried out for industries like Visakha Steel Plant, Visakha Port Trust and Visakha Diary, which are situated in and around Visakhapatnam city. The savings with reference to water quantity and money were estimated for various organizations. It was found from initial water supply balance studies that in VSP, the water that can be saved without any additional investment is 87.372 million gallons per day. This saves an amount of Rs. 0.9783 crore per day. It was also found that the water could be reduced up to 80% by using recycled water.

### INTRODUCTION

With the advancement of civilization, the utility of water enormously increased and now such a stage has come that without well-organized public water supply schemes, it is impossible to run the present civic life and develop the towns. It is certain, however, that without water that is readily available in adequate quantity there would be no life of any kind on the earth. In addition to the direct use of water in our homes and on farms, there are many indirect ways in which water affects our lives. In manufacturing, generation of electric power, transportation, recreation and in many other ways water plays a very important role. In all countries water requirement for domestic and industrial purposes is constantly on the increase. The satisfaction of these requirements becomes increasingly difficult due partly to the limited capacity of water and partly to the ever-growing pollution of the surface and groundwater. Already there are acute shortages of both surface and underground waters in many cities in the world. The pollution of streams, lakes and underground water sources has greatly impaired the quality of water and thereby reducing the availability of water quantitatively. Therefore, it is utmost important for good conservation and sanitary measures be practiced by everyone.

Water auditing will be very useful to estimate the water losses and savings. Water audit identifies water uses such as sanitation, irrigation, heating and cooling process and maintenance of the

distribution system. Unaccountable losses are investigated and areas are identified in which water use efficiency can be improved using alternative technologies or practices. Comprehensive audits can give the utility a detailed profile of the distribution system and water users, allowing appropriate management of water resources and improved reliability. It is an important step towards water conservation and linked with a leak detection plan that can save the utility a significant amount of fresh water and time. Therefore, water supply balance studies are an important part of water auditing (UNICEF 2001).

The water supply balance studies were carried out for industries like Rashtriya Ispat Nigam Limited (RINL), Visakha Port Trust (VPT) and Visakha Dairy. The savings with reference to water quantity and money were estimated for organizations viz., Rashtriya Ispat Nigam Limited, Visakha Port Trust, Visakha Dairy, Bharat Heavy Plates and Vessels, Hindustan Shipyard Limited (HSL), and East Coast Railways, Visakhapatnam. It was found from the initial water supply balance studies, that in RINL the water that can be saved without any additional investment is 87.372 million gallons per day, this saves an amount of Rs. 0.9783 crore per day. It was also found that the water demand could be reduced up to 80% using recycled water. Visakha Port Trust is drawing an excess quantity of 2 lakh gallons per day and wasting an amount of Rs. 90,000 per day as electric charges. In Visakha Dairy there is a possibility for recycling the wastewater quantity of 51327.43 gallons per day. The study also revealed that AU is drawing an excess quantity of water than required. Hi-Grated Pellets Limited is drawing 4 lakh gallons per day of water from Visakhapatnam Municipal Corporation (VMC), even though they do not need that much quantity of water daily. In HSL Township, there is 50% wastage during water supply only, and there are no stopcocks to the pipes. It was found that using treated sullage, the required water demand would be reduced and resulting savings in water and money too.

**Water Quantity Crisis:** About 70% of the total freshwater available is being used to meet the agricultural demand. The World Water Council believes that by 2020 we shall need 17% more water than the available to feed the world. It is estimated that another 45 million hectares (111 million acres) would be under irrigation by 2030, requiring an increase of 14% in water used for irrigation. By the year 2025 the number will explode five-fold to 2.8 billion people which is 35% of the world's projected population. In 1996, people used an esteemed 54% of all accessible freshwater that may go up to 70% by the year 2025.

A country faces water stress when annual water supplies drop below 1,700 cubic meters per person. Water-scare countries have annual water supplies of less than 1000 m<sup>3</sup> per person. At present, thirty-one countries are facing the stress of water scarcity. By 2025 population pressure will push another 17 countries including India on to the list. China, with a projected 2025 population of 1.5 billion, will not be far behind. Even in the United States, where there is plenty of water on a national basis, in some areas, people are depleting groundwater reserves at 25% greater rate than the rate at which nature can replenish (Water Conservation 2001).

**Water Quality Crisis:** Most of the developing countries in the world are caught trying to meet a growing demand for freshwater with fine and increasingly polluted water supplies. Even in the face of impending shortages, water pollution continues to spoil this essential resource. Agriculture is becoming a polluter along with industries and municipalities. Virtually every country where agricultural fertilizers and pesticides are used, they have contaminated groundwater aquifers and surface waters. Over 90% of Europe's rivers have high nitrate concentration, mostly from agrochemicals. In developing countries, on average, 90% to 95% of all domestic sewage and 75% of all industrial

wastes are discharged into surface waters without any treatment.

In India, 14 major rivers are badly polluted and over three-quarters of China's 50,000 kilometres of major rivers are unable to support fish because of overuse and pollution of water bodies. Globally over 20% of all freshwater fish are endangered or vulnerable, or recently become extinct (Schroder Milk Co. 1996).

**Water Crisis in India:** A major freshwater crisis is gradually unfolding in India, slowly undermining many of the success highest standards of health, this crisis endangers the economic and social prosperity of the country. The freshwater crisis is already evident in many parts of India; varying in scale and intensity at different times of the year. Many freshwater ecosystems are degrading. India's rapidly rising population and changing lifestyles increase demand for freshwater.

**Necessity of the Study:** The present population of Visakhapatnam city is around 40 lakhs. Visakhapatnam Municipal Corporation (VMC) is supplying potable water to the entire population and 34 industries, which are situated in and around the city. In addition to VMC supplies, ground water is being used to meet the water demand. As the groundwater is of poor quality, most of the people and organizations depend on VMC for treated water supplies for their potable water requirements. The major problem confronting the city and its suburban areas and industries is shortage of water. Since the turn of this century, a number of investigations made and new techniques have been made in search for new sources of water and reuse of water and wastewater to meet the needs of the growing demand of water for residential, commercial, and industrial supplies in Visakhapatnam city.

It has been observed that the water levels in the reservoirs and groundwater table are getting dropped, which is due to the lack of rains and non-availability of infiltration galleries and also because of seepage losses. This leads to the study of reuse of treated wastewater and water auditing in residential, commercial and industrial sectors to minimize the water usage. It is clear that in this industrialized city, water demand is more, whereas the availability of water is less. Hence, it is necessary to make the water audit study in Visakhapatnam. Water audit deals with the wastage of water and reuse of water thereby saving freshwater resources, which are scarcely available.

**Scope and Objective of the Study:** The world's water crisis is so severe that it could take almost 80 years to eradicate hunger. The world, in general, and India in specific, experiencing severe water crisis, because of the gap between freshwater demand and availability of water resources. This made us to think about the freshwater resources that are available and how much water has been used, how much water is saved and how much water is being wasted in industries, domestic and commercial sectors and how much water is being wasted because of negligence, leakages and thefts.

**Scope of the Study:** In this study, we have taken one small industry, Visakha Dairy, and one large industry, Visakha Steel Plant and Housing complex of Visakha Port Trust, and preliminary water auditing was carried out. The water quantities received or collected from various water resources for distribution, water losses and effluent water (wastewater) were evaluated for the selected organizations by preliminary water auditing. The water supply data showing the bulk water supply to the selected industries have been collected from Visakhapatnam Municipal Corporation (Agreement Quantities).

Water quantities supplied to different units in each organization through distribution, the water losses and water unaccounted at the time of distribution, and recyclable water component from the water wasted after specific usage of water are to be estimated. The water auditing study leads to water supply data classification, estimation of collection-supply gap, recyclability, and savings in terms of

water quantities and financial savings.

**Objective of the Study:** Visakhapatnam city is experiencing rapid industrial growth, so the population is bulging out increasing demand for freshwater. But, it was noticed that the existing surface water levels in the reservoirs and nearby rivers and groundwater table levels and available water quantities are far below the requirements.

The major objective of the study is to suggest a way to local water bodies and households and industries to assess the wastage of water and the quantity of water that can be reused, by conducting preliminary water auditing and water budgeting. Because of the water auditing one can save not only water but also money. Reducing water use can make an operation more efficient and save the money on the volume of water used and treated. A number of conservation practices can reduce water use, including:

- Understand your water flow
- Reuse water
- Use high-pressure, low volume wet cleaning systems
- Optimize nozzle use
- Prevent leaks
- Turn water off when not in use
- Train employees
- Create water use incentives

Hence, an attempt is made to quantify the water losses, and thereby financial burden, in some organizations in Visakhapatnam.

**Water Auditing:** Water audit identifies water uses such as sanitation, irrigation, heating and cooling, process and maintenance. The audit then compares the sum of the individual uses to the total use at the facility. Unaccountable losses are investigated and areas are identified in which water use efficiency can be improved using alternative technologies or practices.

A water audit determines the amount of water lost from a distribution system due to leakage and the cost of this loss to the utility. Water audits balance the amount produced with the amount billed and account for remaining water (loss). Comprehensive audits can give the utility a detailed profile of the distribution system and water users, allowing easier management of resources and improved reliability. It is an important step towards water conservation and linked with a leak detection plan which can save the utility a significant amount of money and time. Elements of the facility audit include:

- Record of the amount of incoming water.
- Identification of each water use at the facility.
- Estimation of the quantity at each use point.
- Determination of amount of water loss (leaks and other unaccounted water).
- Development of a plan to conserve (e.g., replacement fixtures, leak location and repair, employee water use education).

**Benefits of water audit:** Benefits of an audit include improved knowledge and documentation of the distribution system including problem and risk area. The audit also becomes a valuable tool to manage resources by getting a better understanding of what is happening to the water after it leaves the treatment plant. Leak detection programs are effective ways to minimize leakage and to fix small problems before they become major ones (Water Supply Program-Conducting a State Facility Water

Audit 2002).

According to the American Water Works Association, these programs lead to reduced water losses, financial improvement, increased knowledge of the distribution system, more efficient use of existing supplies, safeguarding public health and property, improved public relations, reduced legal liability, and reduced disruption to customers.

**Perform water audit:** A water audit can be completed in one day if meter-reading records are easily available and significant adjustments to the records are not necessary.

Audits are completed by calculating the difference between the amount of water produced and the amount sold (metered sales) and then addressing the difference. Metered sales are compiled and remaining difference between produced water is lost. Before undertaking the audit, the utility should take time to plan and design the study. The audit should use existing records as much as possible to produce the most accurate results. An audit records the amount of water produced, amount delivered to metered users, amount delivered to nonmetered users and water loss, along with likely causes for the unaccounted water. Then the results are analysed and estimates are made for recoverable leakage. Corrective measures should be evaluated and any needed distribution system improvements should be described. Cost benefit analysis should be performed and an effective course of action implemented.

Once the efficiency of the water system is evaluated, the system should take necessary steps to reduce the amount of recoverable water loss. Effective water audits usually result in leak detection programs, which identify and correct problems in the distribution system. A comprehensive follow up audit might be necessary to determine the accuracy of meters, track nonmetered use, and locate and repair leaks.

**Planning the Water Audit-Considerations:** Water audits can be designed by reviewing the system records and staff expertise and using these resources to develop and complete effective worksheets. Distribution system characteristics vary, so each utility will have different challenges in performing the water audit. Each system will need to decide how can it perform the audit accurately with the least cost. A worksheet should be developed and a study period set.

**Set Study Period:** A study period should be getting to allow an evaluation of the complete water system. One year is recommended because it includes all seasons and gives enough time to eliminate the effect of meter reading lag. Shorter periods might not give a complete picture of the water system and longer periods can be difficult to manage.

**Develop a Worksheet:** A worksheet, similar to an accounting spreadsheet should be developed that will make the computations clear and allow the utility to balance water produced with water used as well as balancing water in and out of the distribution system. The worksheet should list and account for various water usages.

Water is the commodity and assets (water produced) will be balanced with liabilities (water sold) to determine the loss of commodity. If the worksheet is properly designed, a preliminary audit should be able to be completed in a day if using existing meter reading data. Worksheets can vary in detail and will determine how well the distribution system is described. A more detailed worksheet will provide better understanding of the water usage and could be useful tool for the water utility.

**Water Losses:** There are two types of losses, real and apparent losses. Real loss includes water lost through leakage of distribution systems, service connections, and storage tanks (including overflow).

Apparent loss includes meter and record inaccuracies and unauthorized water uses such as theft and unauthorized connections. Authorized unmetered uses can be considered a special type of lost water, and they can also represent lost revenue so should be estimated carefully.

**Data Collection:** The data required for preliminary water balance studies for RINL, VSP, VPT and Dairy industries were collected including the data containing water quantities that are being drawn from the water source and water supplied to each industry like Rastriya Ispat Nigam Limited, VSP(Visakha Steel Plant), Visakha Port Trust, and Visakha Dairy, Bharat Heavy Plated and Vessels, Eastern Railways, Hindustan Ship Yard Limited, Hi-grated Pellets Limited and Andhra University, Visakhapatnam. The water supply data for preliminary water supply audit is presented in the following sections.

### Calculations of Water Savings

**Steel Plant (RINL):** Steel plant draws 920.497 million gallons of water from Yeleru reservoir for plant consumption and steel plant township demand and also supplying 5.848 million gallons of water quantity to Gajuwaka municipality. According to steel plant authorities, it is supplying a quantity of 665.125 million gallons of water per day to plant, administration buildings and township and also to Gajuwaka municipality. It has been observed that either during the intake or during the conveyance and distribution of the water, 255.372 million gallons of water is being wasted daily. And also there are many evaporation and seepage losses. The total water supply losses in RINL, Visakhapatnam are estimated, and it was derived that the water loss due to evaporation and seepage is 25.25% of the total water intake. In any water supply system the total water losses should be less than 10% (Narian 2000).

The quantity of water that is circulating in the distribution network is 33.63 million gallons per hour. The total quantity of freshwater supplied to various processing units in the plant for their consumption per hour is  $575.2772/24 = 23.98$  million gallons. Based on the data collected, 98% of wastewater is being either recycled or treated for reutilizing. It implies that only 2% of the water is coming out of the plant as wastewater. If this is taken into consideration, the unaccounted quantity of water is 9.65 million gallons per hour only.

If there are at least 10% losses due to leakages in the distribution network, then by regulating the losses RINL can save a quantity of water up to 6.2955 million gallons per hour ( $33.63 \times 0.9 - 23.98 = 6.2955$ ). It is estimated that in urban water supply almost 30 to 40% of the water is wasted through the distribution system.

Therefore, it is 9.66 million gallons per hour of water that is in circulation in the distribution network system has not accounted. So it is advisable to draw a quantity of water 23.97 million gallons per hour of water, instead of 33.63 million gallons per hour, which saves considerable amount of water and also money too. When there is chance of 98% reutilization or recycling of water, one again need not to draw the same quantity of water daily. If it is correct that 98% recycling is possible, then it is advisable to draw only remaining 2% only from Yeleru reservoir.

According to the data collected, the wastewater quantities are as follows:

1. Treated effluents 0.664 gallons per hour.
2. Neutralized effluents 0.442 gallons per hour.
3. Township sewage water 0.442 gallons per hour.

**Visakha Port Trust (VPT):** VPT uses freshwater received from VMC to meet their residential and

commercial needs. Hence, VPT can save water by arresting or reducing distribution leakages and recycling of sullage. Sullage (water from kitchens and bathrooms) is treated and recycled for toilet flushing and gardening. By reducing the requirement of freshwater by 60%, it can be made available for drinking, cooking, bathing and laundry (Environment and Water India, 2000). In the total water per capita requirements of 135 liters (Indian standards), if the water requirement component (30 L) for flushing purpose is met through recycled water, then VPT can save a water quantity of 2,49,010 gallons per day. The water that can be saved in each residential or commercial area, is computed and Table 1 shows the quantities of water savings from different locations or areas.

Therefore, the total amount of freshwater that can be drawn from VMC if VPT practices recycling = total quantity – total savings, = 1306000 – 249010 = 1.057 lgpd.

Hence, VPT can save 19% of freshwater by stopping flushing using freshwater quantity of 30 liters per capita per day. In addition to this, if leakages and other losses in the distribution system, which amounts to 30-40% (Narian 2000) of the total supply, are checked, VPT can save more freshwater.

**Visakha Dairy:** Dairy needs a water quantity of 2.22 lakh gallons per day to meet water demand of the plant, but VMC is supplying only 0.77 lakh gpd of water. Hence, Visakha dairy is pumping water from bore wells into the plant and also purchasing water from private water suppliers. Instead of purchasing water from private water suppliers at higher price, it is advisable to go for recycling of the wastewater that is coming out of the processing units. This will save not only the freshwater but also money. If Visakha dairy is able to recycle the wastewater after taking appropriate measures, then pressure on the daily water needs will get reduced. It saves lakhs of rupees per year. The recyclable component of the wastewater of each processing unit is computed based on their respective general characteristics. The computed water quantities are presented in Table 2.

The recyclable quantity of water = 51327.43 gallons

Total quantity of freshwater required after using recycling water = 1.7 lakh gallons/day (approx.)

Net wastewater after recycling = 1.14 lgpd

The percentage of wastewater = 68.89 % ( $1.13673/1.65 \times 100$ )

According to data collected from Visakha dairy, wastewater from different processing units is 1.65 lakh gallons per day.

Total percentage of wastewater from processing units =  $1.65/2.2124 \times 100 = 74.58\%$

Therefore, percentage reduction in wastewater =  $(74.58 - 68.89) = 5.68\%$

(2.21 lakh gallons is the quantity of freshwater being supplied to processing units). The quantity of wastewater after 50% recycling =  $0.5 \times 1.65 = 0.825$  lgpd.

The percentage of water can be saved after recycling the wastewater =  $0.825/2.2124 \times 100 = 37.29\%$

Reduction in the wastewater effluents quantity =  $1.65 \times 0.373 = 0.6153$  lgpd

**Cost analysis:** Water savings in an organization is important to the community of that organization at micro level and to the country at macro level. It is essential to know the direct benefits to the organization because of the water conservation and water auditing. Hence, cost analysis is carried out to know the financial savings or benefits to the organization at a charge of Rs. 25 per 221.24 gallons

(charge of VMC). Using this price, the cost of water saved is estimated. But, one has to note that the water cost will increase day by day, leading to more financial savings in future than those estimated today.

## RESULTS AND DISCUSSION

The initial water supply balance studies were carried out using the water supply data collected from various organizations. A major industry, Visakha Steel Plant, with required quantity in million gallons per day and a minor industry with required quantity of two lakh gallons per day, and Visakha Port Trust and Andhra University were taken up for the study. The data of each industry were analysed. The initial water quantity that is being drawn, water quantity that is wasted, and the water quantity that can be saved with and without using recyclable water are estimated. Based on the analysis of the water supply data, the results are presented.

**Steel plant (RINL):** According to RINL and Visakhapatnam water supply data, they are drawing 920.5 million gallons of water per day and in that 575.277 million gallons of water per day is being supplied for various processing units in the plant, and 84 million gallons per day for township and administration buildings. They are supplying 5.848 million gallons per day to Gajuwaka Municipality. It implies that for various usages, a total quantity of 665.125 million gallons per day of water is being supplied.

Through the water balance study, it was found that the gross water supply losses or wastages in the plant are 255.372 million gallons per day and the evaporation and the seepages losses are 168 million gallons per day. Even after accounting for the evaporation and seepage losses, 87.372 million gallons per day of water is being wasted. This water can be saved by proper water supply management and without any additional investment. The amount that can be saved per day and per annum is Rs. 0.9873 crore and Rs 360.3645 crore respectively.

Water supplied to different processing units will be discharged as an effluent after utilization. The wastewater coming out of some processing units can be reused after primary treatment. The total quantity of water that is supplied to the processing units, from which the wastewater can be recycled, is estimated and found. A part of wastewater can be reused if treated sufficiently. It may need some additional investment to segregate the outflow water stream from these wastewater streams, which are not reusable after primary treatment. It is found that 246 million gallons per day of freshwater can be saved by reusing 50% of recyclable wastewater. It leads to the financial savings up to Rs. 2.781 crore per day.

The water savings may lead to the reduction of effluent quantity that is to be treated. This in turn reduces the financial requirements of effluent treatment plant construction and effective operation and maintenance.

The water savings discussed above may increase if proper water management practices are implemented. It is essential to conduct comprehensive water auditing in the Rashtriya Ispat Nigam Limited, Visakhapatnam to arrive at proper water management programme. Water auditing, thereby water saving is very important for an industry or organization because of the forecasted acute water shortage in the world.

**Visakha Port Trust:** VPT has a storage tank at OHC pump house, and it has the storage capacity of 2 lgpd. It was found that the water in this tank will be used in emergency times, but VPT is drawing the same quantity of water daily from the wells situated in the different localities under VPT, which



is leading the wastage of money through electric bills. The amount that is being wasted by VPT was found to be Rs 90000 per day.

**Visakha Dairy:** Considering the recycling process and reuse of the water after treatment will give more flexibility in the water use and less pressure on the water demand and also economically it saves money. It has been seen that after treating the effluents, every industry is discharging the wastewater. But it is advisable, if possible, recycle the wastewater and then go for the effluent treatment and discharge it onto land or into rivers.

The recyclable quantity of water from the dairy processing units is 51327 gallons per day and the money can be saved is Rs. 5800 per day, then the amount that can be saved per year is Rs 21.17 lakh, and by conducting 50% recycling, the quantity of water can be recycled is 0.825 lakh gallons per day, and the amount that can be saved per year by adopting recycling processes is Rs. 3.544 crores.

Table 1: Water saving details at different locations under VPT.

Location	Quantity (gpd)
SG Puram	80081.86
Harbour park	22462.74
SS Nagar	4792.798
CISF	8880.531
OHC	132000
MR Peta	792
Total	249009.9

Table 2: Details of water quantities that can be recycled in processing units.

Processing units	Quantity of water (gpd)
Cooling tower	2654.867
Spray pond	1106.195
Domestic	17699.115
Plant cleaning	29867.257
Total	51327.434

## CONCLUSIONS

- After studying the initial water balances and chemical characteristics of the different processing units of the each industry for recycling the wastewater, and by using the treated wastewater, the initial water requirement of each industry got reduced. Based on the present study the following conclusions are made.
- RINL water consumption was initially reported as 807.1 mgpd, but water balance survey revealed that actual water that is circulating in the plant is 575.277 mgpd. Present study also revealed that the gross water supply losses or wastages in the distribution network of the RINL are 255.372 mgpd.
- This water balance survey also found that RINL is drawing same quantity of water daily, even though they are accomplishing 98% (according to the RINL statement) recycling, for plant processing units, which may not be true.
- Present study also revealed that there is a wastage of freshwater quantity of 168 mgpd through evaporation and seepage losses.
- The survey found that the quantity of water that can be saved with proper water distribution system in the plant considering the quantity of water that is being circulated in the plant and township and Gajuwaka municipality is 141.975 mgpd. The money that can be saved is Rs. 1.6 crore per day. The water that can be saved without any additional investment is 87.372 mgpd that amounts to Rs. 0.9873 crore savings per day.
- In RINL, 492.197 mgpd of freshwater could be recycled and reused. Hence, total quantity of water that can be saved by reducing losses and using water from recycling process is 498.670 mgpd, which saves Rs 5.635 crore per day.
- The VPT water requirement data reported that they need a water quantity of 15.6 lgpd and they are drawing the same quantity of water daily from VMC and wells. But, the present study re-

vealed that earlier VPT had drawn 24.26 lgpd of water, at present VPT is able to meet their demand with 15.6 lgpd only, which made an impact on the financial savings of the VPT and affected the VMC water supplies. Present study also revealed that VPT is storing a quantity of 2 lgpd in a storage tank from SS Nagar to OHC pump house, but they are drawing the same 2 lgpd of water daily, which is causing a wastage of money of Rs. 90000 per day through electric charges.

- In Visakha dairy, there is a possibility of recycling the wastewater quantity of 51327.43 gallons per day. Hence, Visakha dairy can save Rs. 21.17 lakh per day and at 50% recycling of the total quantity of wastewater (1.65 lgpd), an amount of Rs 3.5444 crore per year can be saved.

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