

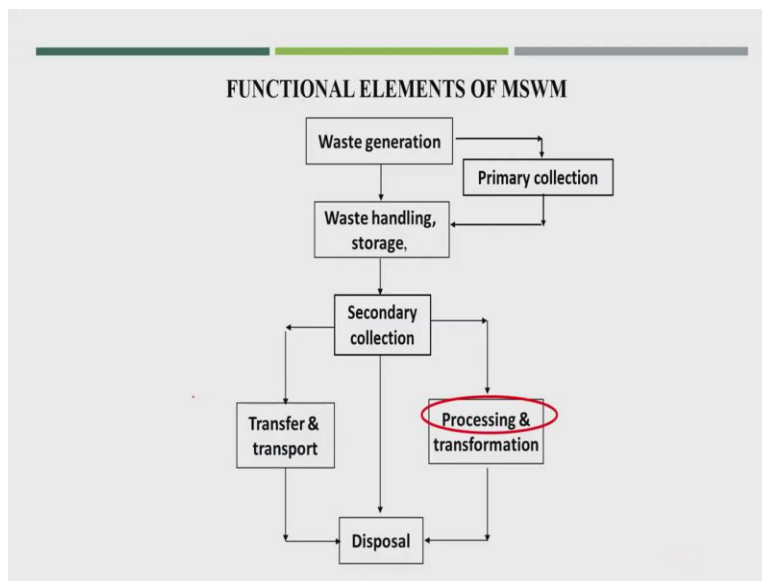
Municipal Solid Waste Management
Prof. Ajay Kalamdhad
Department of Civil Engineering
Indian Institute of Technology, Guwahati

Lecture No - 17
Material recovery facilities (MRF)

So hello, students this is what we were discussing in the previous class about unit operations, which is required for the recycling process. So today we are going to talk about MRF the material recovery facility, and again also in one more video so that you people can understand how this unit operation will operate inside the MRF stations. And also I have one more special video from Indore which is the well-known city now in India, one of the cleanest city.

So they also started some material recovery facility that also, I will show and also discuss about some of the important design criteria about MRF also, what are the different issues need to be discussed before finalizing the MRF location.

(Refer Slide Time: 01:25)



Wherein the same functional element so, this lecture on material recovery facility. So, before directly going to the material recovery facility I will just talk about what you can remember a drop off centre.

(Refer Slide Time: 01:43)

DROP OFF CENTRE

- ❑ A **drop off centre** requires the waste producer (residents) to carry the recyclable material to a separate location, either an installed or mobile collection station or the reprocessing plant itself.
- ❑ They are an easy type of collection to establish.
- ❑ Throughput may be low or difficult to predictable.



A drop-off station in IPC shopping center, Malaysia

Maybe in India this word never had been used but the in the European country and developed country this is one of the very well on word is a drop off centre and buy back centers also which I am going to show in the next slide. So what do you mean by this drop of centre is to drop the recyclable matter from the residential centres from local residents in one of the location. Ok so this type of centre could be possible in any residential location specially in the commercial area.

There could be one special location where anybody any residential people or commercial person can drop the recyclable matter and specially the bigger size of waste recycle matter like table or any bigger kind of materials which is difficult to store in the household dustbin, how we can give it to the collection person? It is very difficult and these all things are recyclable one. So those things we can put into the drop-off center.

So you can see here one of the drop-off centre in Malaysia so where anybody can go and the Drop the recyclable matter and one more like some of the countries like Malaysia Indonesia also when they started the awareness for segregation of the waste. They also started this kind of drop off centres and anyone will give the here the waste dry waste recycle matter. They will get some kind of another item. They will get it from the centre so that more people can come and drop the recyclable matter into such station.

This was very one of the very easy method to get the recyclable matter specially the bigger kind of material which cannot be collected, the collection crew, primary collection crew or which is somewhat difficult to transport the wastes from the one location to another location. So this was a very good idea, in India I think the drop off centres have now started but at least in the Swachh Bharat mission corporation is asking to give to the crew member itself.

Whatever could be recyclable material is getting produced. This is another drop off plants in Malaysia. So here you are seeing, people are paying off money and someone is collecting their waste to the drop off centres.

(Refer Slide Time: 04:43)

BUY BACK CENTRE

- ❑ A **buy-back centre** enables the residents to purchase clean recyclable material, providing a clear incentive for use and creating a stable supply.



A buy-back center in California, USA
Source: <https://www.mingsrecycling.com/buyback/>

And now is another one is Buy Back Centre. So it is also possible that somebody is disposing the and the same way as could we could be possible to utilize other people. So in the same location in the drop-off centre itself could be possible to have Buy back Centre also the same old material is getting by buying by the; maybe some of the residential people or could be possible that some somebody the recycling people those who are recycling they can also buy waste from this kind of stations.

So here one of the photograph is of a buy back center, again in the Malaysia to easily established distance to purchase clean recyclable material and the same material they can be also used for other purposes. These are buyback rate also these same from the Malaysia. So, cardboard,

magazines, newspaper plastic, metal so they will get some kind of money or some kind of money they have to pay to buy this kind of different recyclable matter.

Ok you can see it especially the aluminum and is very costly. So by that some amount of money will get it by the; this buy back center also can be useful for the local Corporation. This is another buy back Centre, and it could be possible that in the same location is a drop off center and same location buy back centre can be possible.

(Refer Slide Time: 06:28)

□ Many programmes have made drop-off centers encouraging for the participation of waste producers (residents of households).

□ Such centers have been made convenient to use in different ways such as-

- ✓ Drop off points at shopping malls.
- ✓ Combination of buy-back and drop-off centres at MRF.
- ✓ Mobile collection centres, which can be periodically moved to different locations.

COVE RECYCLING

COVE buy-back recycling center in California, USA

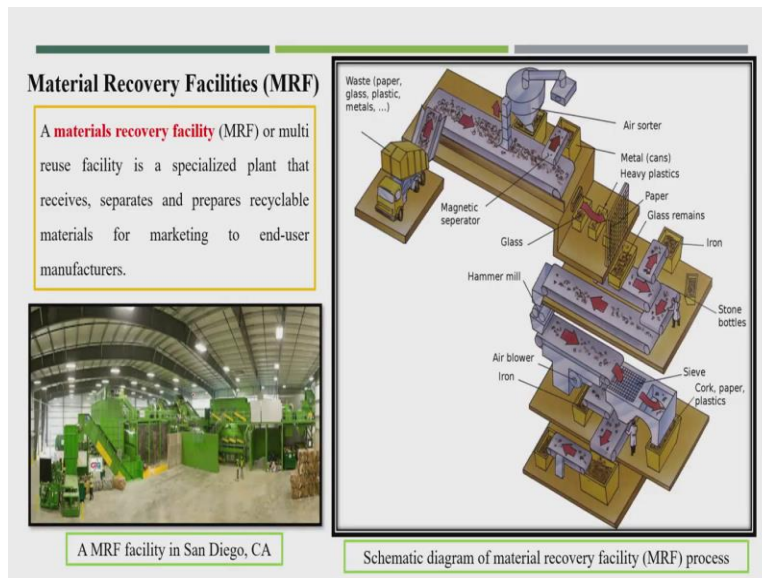
This is another Buy Back Center this is in USA so this many programs have introduced drop off centre to increase the awareness among the local people are participation or more people and more residential household people, some centers have been made convenient to use a different way such as like the pour point is the shopping mall because most of the people are going to the shopping mall so that there is there finding the drop-off centre there so they can come up with this kind of recycle matter and can drop into the shopping mall itself.

and combination of buy back and drop off centre at MRF that is also one of the thought behind the combination of the both drop off and buy back centers and mobile container centre which can be periodically moved to the different location. So this is also possible that the rather than having the only one location this drop off centers are buy back centers could be a mobile container

facility could be possible. So, these mobile containers can go in the different, different area and may be in the day wise of week wise.

They can be a one location next week the next week will go to the another location so by that way lot of amount of recycled matter will come up very easily to the local authorities.

(Refer Slide Time: 08:03)



So now I will go for MRF ok material recovery facility. So in material recovery facility or multi facility is a specialized plant that receive separate and prepare recyclable matter for marketing to and user manufacturer. That is the major idea about the MRF material recovery facility which will receive the lot of amount of dry matter which will get separated also and also prepare the material for the subsequent use or could be due to the end user manufacturers.

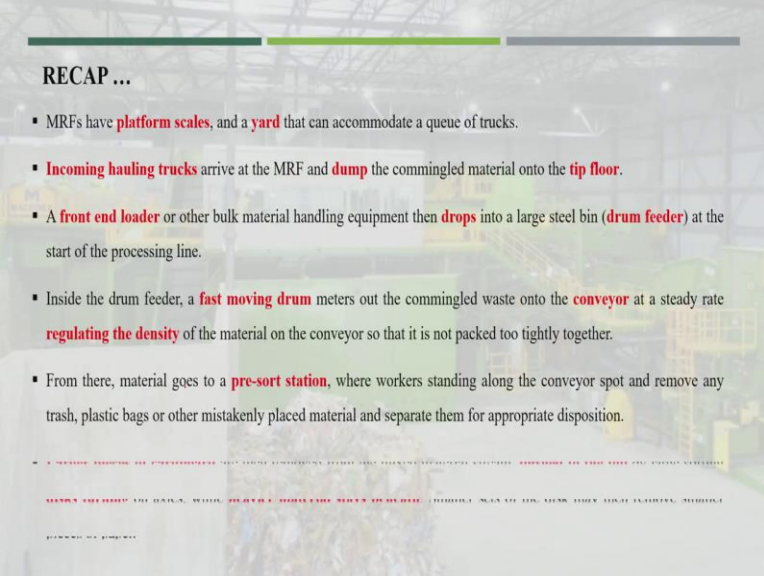
So you can see it here this is a unit operations only for the separation purpose in the MRF this is one of the; another photograph from the US.

This is what one video around 5-minute video how this material recovery facility will work for how this will show inside MRF facility. Actually this is how this unit operation will work together inside the MRF facilities.

Video Start Time: 09:17

Video End Time: 14:10

(Refer Slide Time: 14:12)

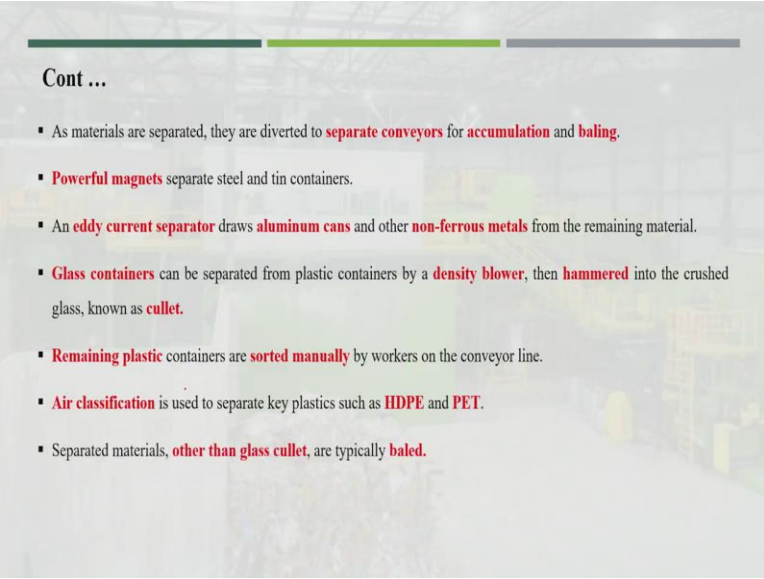


RECAP ...

- MRFs have **platform scales**, and a **yard** that can accommodate a queue of trucks.
- **Incoming hauling trucks** arrive at the MRF and **dump** the commingled material onto the **tip floor**.
- A **front end loader** or other bulk material handling equipment then **drops** into a large steel bin (**drum feeder**) at the start of the processing line.
- Inside the drum feeder, a **fast moving drum** meters out the commingled waste onto the **conveyor** at a steady rate **regulating the density** of the material on the conveyor so that it is not packed too tightly together.
- From there, material goes to a **pre-sort station**, where workers standing along the conveyor spot and remove any trash, plastic bags or other mistakenly placed material and separate them for appropriate disposition.

So you so the video the video is again, the unit operations how they are working together and along with the mechanical facilities also it requires a lot of manpower's for manual segregation also for different material. It is simple recap. You can read it as a notes and the similar one I think I tried to save the video, the different points I put it in the slide ok similar way. So the larger pieces of cardboard are getting removed from the mixed material.

(Refer Slide Time: 14:51)



Cont ...

- As materials are separated, they are diverted to **separate conveyors** for **accumulation** and **baling**.
- **Powerful magnets** separate steel and tin containers.
- An **eddy current separator** draws **aluminum cans** and other **non-ferrous metals** from the remaining material.
- **Glass containers** can be separated from plastic containers by a **density blower**, then **hammered** into the crushed glass, known as **cullet**.
- **Remaining plastic** containers are **sorted manually** by workers on the conveyor line.
- **Air classification** is used to separate key plastics such as **HDPE** and **PET**.
- Separated materials, **other than glass cullet**, are typically **baled**.

Likewise, finally that air classification used to separate key plastic such as HDPE and PET.

(Refer Slide Time: 15:06)

DIFFERENT TYPES OF MRF

1. Clean MRF

- ❑ It receives source-separated (segregated MSW from residential or commercial sources) mixed recyclable materials.
- ❑ There are different types of clean MRFs -
 - ✓ Single stream (all recyclable materials are mixed).
 - ✓ Dual stream (source-separated recyclables are delivered in a mixed container stream consisting of glass, ferrous metals, plastics (PET and HDPE), aluminum and other non-ferrous metals).
 - ✓ Mixed paper stream (corrugated cardboard boxes, newspapers, magazines, papers from offices).



So now will go for different type of MRF so there are two major type of MRF the first is the clean MRF ok and other is a dirty MRF. So that discussion will do it later on the first we will see that what do you mean by clean MRF? So the clean MRF are one which receives source segregated mixed recyclable material or segregated MSW from residential commercial sources. Segregated means there is no biological material into the segregated material.

Which already we are talking from the last few lectures already segregated in household level dry waste and wet waste. So only these dry waste which is a mixed one of different, different recyclable matter of combustible matter which is getting received at the clean MRF. This is one of the photo of clean MRF. So there are different types of again the type of clean MRF the first is a single steam. That is a all recyclable material or mixed.

So, all the recycled material mixed together. Ok so you can see here the entire all kind of materials are together. So, lots of manual creations are required in that case. Next is the dual stream are source separated recyclable are delivered in a mixed containers steam consisting of Glass, ferrous metal, plastics, aluminum other non ferrous metal that is a dual stream. And another one is mixed paper stream. So there could be possibilities of the paper stream will be different and the materials like glass, ferrous metal, plastic this will be in the separate stream will come up, so based on that we can see the different type of clean MRF.

(Refer Slide Time: 17:08)

- ❑ As per specifications, materials are sorted, baled, shredded, crushed, compacted, or prepared for shipment to market.
- ❑ The percentage of residuals (unrecoverable recyclable or non-program materials) should not exceed 10% by weight of the total delivered stream and in many cases it can be significantly below 5%.



Clean MRF end product

So this is the; you can see is a one of the photograph of end product in the clean MRF. So this is ready for the shipping to the market or end user manufacturer directly. Ok and the idea behind the clean MRF is that the percentage of residual should not be exceed 10% by weight of the total deliver stream, and in many cases it can be a significant low 5% or less than 5%. So you understand this is the one of the very important issue about the clean MRF.

Mean the idea of the cleaner maximum 10% or even less than 5% non recyclable matter will come from such MRF. So means more than 90% or 95% of materials are recyclable and that directly we can transfer to the end user or for the market purpose. That is the major idea behind clean MRF.

(Refer Slide Time: 18:23)

2. Dirty MRF (Mixed-waste processing facility)

- ❑ It receives mixed solid waste stream to separate recyclable materials through a combination of manual and mechanical sorting.
- ❑ This type of MRF ensures sorting of 100 % of the incoming waste stream leading to a greater number of materials for recovery.
- ❑ This type can recover from 5% to 45% of incoming materials as recyclables (remaining is disposed or landfilled).



Now the dirty MRF that is the mixed waste processing facility also we can say that here it which receives the solid waste stream from the separate recyclable material through a combination of manual and mechanical sorting. Now here entire materials are mixed where biological matters also is there and dry matter is also is mixed together. So that was the idea about the dirty MRF this is a special idea about the commingled waste how best they will be able to separate the recyclable matter.

So this is the one of the photograph of base stream of dirty MRF so the type of MRF that sorting of 100% of the incoming waste stream leading to a greater number of material for recovery. So the idea was that whatever is possible to get the recyclable matter from such kind of MRF, and this type can record from 5 to 45% of incoming material is recyclable and remaining will go to the disposal site or landfill sites.

So, this is a different idea compared to the clean MRF. Here the maximum recovery could go maybe 45% of 50% in India also the 50% is a biological matter. So remaining could be recyclable matter but is not entire it is a recycle matter maybe 20 or 25 % will go inert materials also for construction and construction kind of materials also will come up. This is one of the photographs from USA.

(Refer Slide Time: 20:15)

ADVANTAGES AND DISADVANTAGES OF DIRTY MRF

ADVANTAGES

- Increases participation rates for source-separated recycling collection systems and prepare fuel products and/or feedstocks for conversion technologies.
- Higher recycling rates compared to curbside or other waste collection systems.
- Recovery rates higher than clean MRF.

DISADVANTAGES

- Greater contamination of recyclables (especially paper)
- Challenging process since deals with mixed waste stream.
- Installation is very expensive.
- Operational costs are higher
- Labor-intensive

So now we will see the advantage and disadvantage of MRF. So, the advantage could be increased participation rate for source-separated recycling collection system and prepare fuel product or feedstock for conversion technology. So already there is no source segregation, obviously whatever segregated material will get it or combustible matter will get it that is highly beneficial in this case. So, higher recycling rates compared to the curb site or other waste collection system.

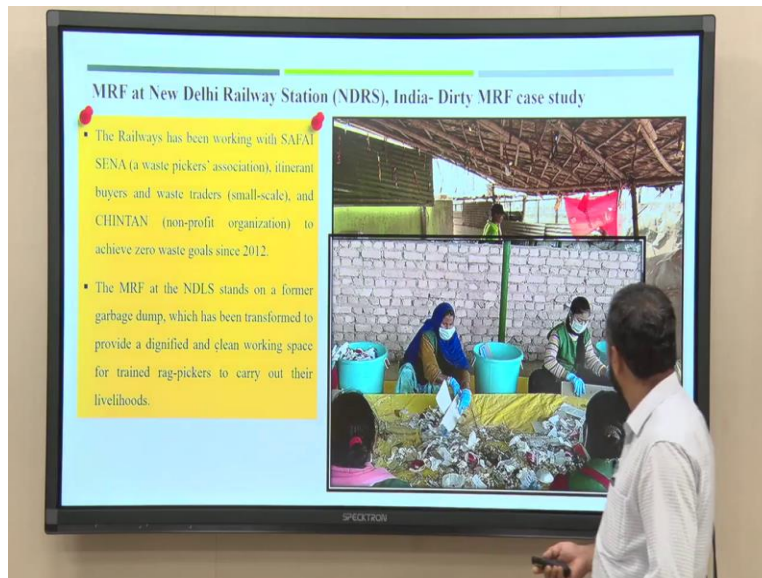
So if the waste collections services or curb correction services, and there are no house to house segregation also in curb entire materials are receiving at the curb area and commingle waste has to be collected by the local authority. So in that case we say it is possible that many of the recycling recyclable matters can come up from this kind of MRF, and the recovery rate higher than the clean MRF.

So here the recovery rate means because there the entirely a segregated material in the clean MRF but here is a mixed one, from mixed one 50% of getting also percentage that is very good in compared to the clean MRF. Now the disadvantage is could be that greater contamination of recyclable. So is possible that when your targeting the plastic separation is obviously possible to get some paper contamination into the plastic that is also possible.

And challenging process since deal with the mixed waste obviously it is very challenging so lot of mechanical as well as manual segregation are required. Installation is very expensive is a

because the dirty one unit operations could be a very strong enough to get the separated material. Operation costs are high, operation costs mean a lot of man powers will be required lot of energy will be required to run the such kind of MRF. Labor intensive obviously lot of man power will be required in this case.

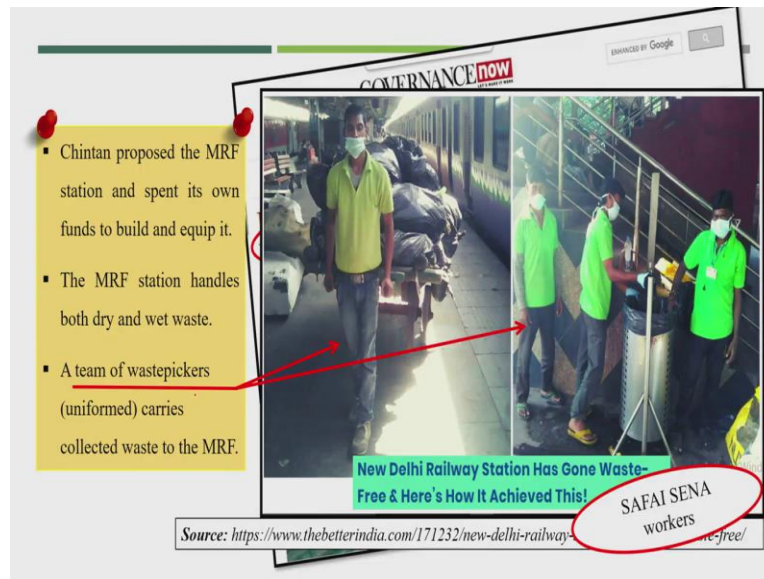
(Refer Slide Time: 22:40)



So this is one of the news I found about MRF at News, in New Delhi railway station before 10 years 15 years when you visit, used to visit the New Delhi railway station. It was very problematic one and waste nobody used to be collect but because of one of the NGO they work together with the New Delhi railway station and they tried to install one small MRF stations operated by the one of the NGO. You can see here one of the case study. So this is a one of the MRF stations in the New Delhi railway station. The railways have been working with Safai Sena. For man power and work with the Chintan that is a non-profit organization one of the NGO with they achieve the zero-based goal since 2012. The MRF at the New Delhi railway station stands on a former garbage dump which has been transformed to provide a Clean working space for the train rack pickers to carry out their livelihood.

So what they had done this New Delhi railway station authority and along with the non-profit organisation. They had as the local rack pickers because already local rack pickers they were collecting the recyclable matters from the railway station. So by along with that they started one small MRF station. So here they were segregating the recyclable matter.

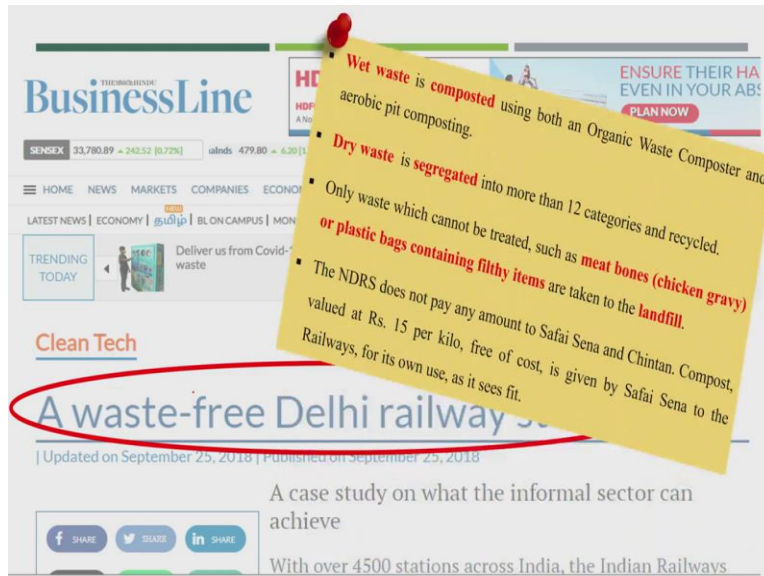
(Refer Slide Time: 24:23)



So this was one news 70 workers were working in the New Delhi railway station. This was the one of the MRF construction. So this non-profit organisation proposal MRF station spend its own fund to build in equip it and which is to be handled this both dry and wet waste but in the segregated way and the team of waste pickers carried collected waste to the MRF. So only the local radicals and uniformed manpower they used to collect the waste they are collecting the waste from the railway station. You can see here these are the team of waste pickers.

They are called as a Safai Sena from the railway station. so all kind of waste whether it is a dry waste or wet waste.

(Refer Slide Time: 25:27)



This was another; news waste free New Delhi railway station having the MRF station. So what they are doing is , the wet waste is composted using both as an organic waste composter and aerobic composting. Dry waste is segregated into more than 12 categories and recycled the same authority only waste which cannot be treated such as meat bones are plastic bags containing filthy items are taken to be taken to a local landfill.

New Delhi railway station does not pay any amount of Safai Sena or Chintan see that was very important thought. This New Delhi railway station authority they never paid any amount to the Safai se or Chintan. The composed values was 15 per kilo and free of cost is given by the by Safai Sena to the railway for its own use and as sees fit. So they were selling the recyclable matter the Safai Sena nad Chintan and they were also selling the composed having value of 50 rupees per kg. So by that they were getting the money for the operation cost they were getting operation money from the by selling of this kind of product.

So this is a one more video. Because what everyone knows is that from last 2 years Indore has become one of the cleanest city or best clean city in India. So they also started the small recycling facilities. So you can see in this video. I think this video in Hindi.

Video Start Time: 27:23)

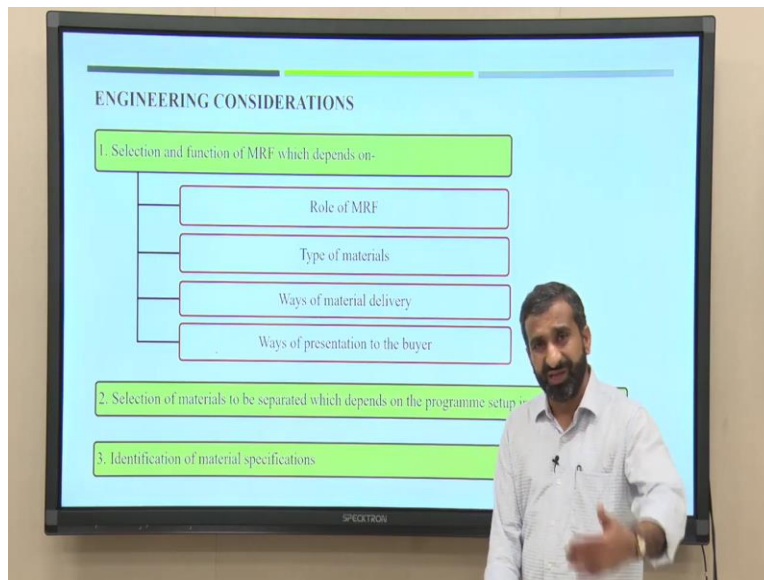
So the thought behind the operation of this MRF here in this MRF station we did not get any kind of mechanical separation facilities because in India we need lot of jobs and there is the

suppose if you start all mechanical separation system where these rag pickers will go. Obviously rag pickers were trying in informal way of collection of these dry matter.

Video End Time: 31:26

So they asked the same rag pickers to segregate manually and based on their segregation they will get some payment also from the local authority.

(Refer Slide Time: 31:42)



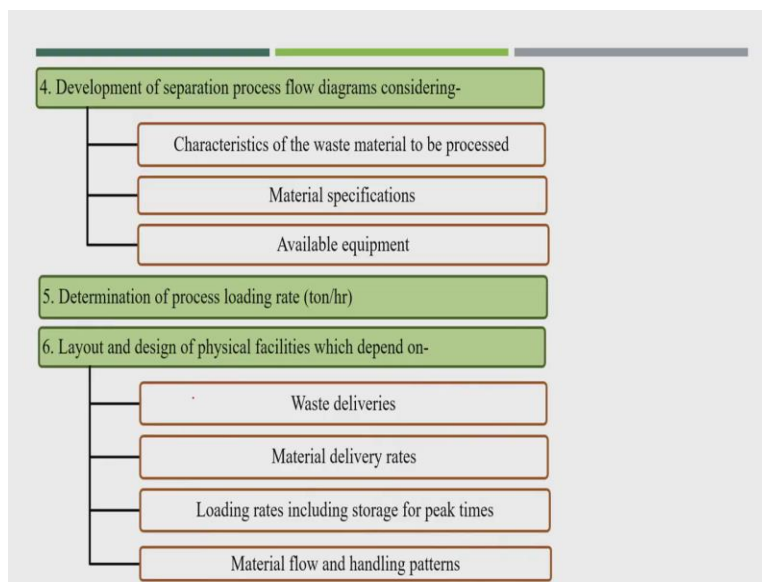
Now we will see the engineering consideration of the MRF station. So whenever we thought of to have the MRF station, so we need to have discussion of Selection function of MRF which depends on what is the role of MRF. Now here we saw the two different videos, one of the video is saying that the entire mechanical system, another is a purely mechanical system objectives are different but objectives are similar also we can say that like both the way they are trying to get the recyclable matter.

So need to be see that what is the function of MRF is possible that sometimes the MRF will work for very specialized kind of material like combustible matter. So in the combustible matter, especially paper, plastic, rubber and leather this will be get only segregated. So, non-combustible matter would not get separated specially. So based on the role of MRF we can finalize the type of material also and the and how best we can prepare to the particular material for the buyers are end users.

Then the selection of material to be separated which depends on the program setup in the community. So this again is a very important one so if already the source segregation has started in the community and so segregated material only receiving by the MRF stations? Based on that also we can finalize that what kind of material. So it is possible that coming always is receiving by the MRF station or separated materials only the dry matters are receiving by the camera station has to be looked upon.

And identification material specification there also, we need to see how much percentage of recyclable matter is there we are getting it and in India lot of inert content also is available. So that also need to be see that how much percentage of recyclable matters is possible to get it from the material received by the MRF station.

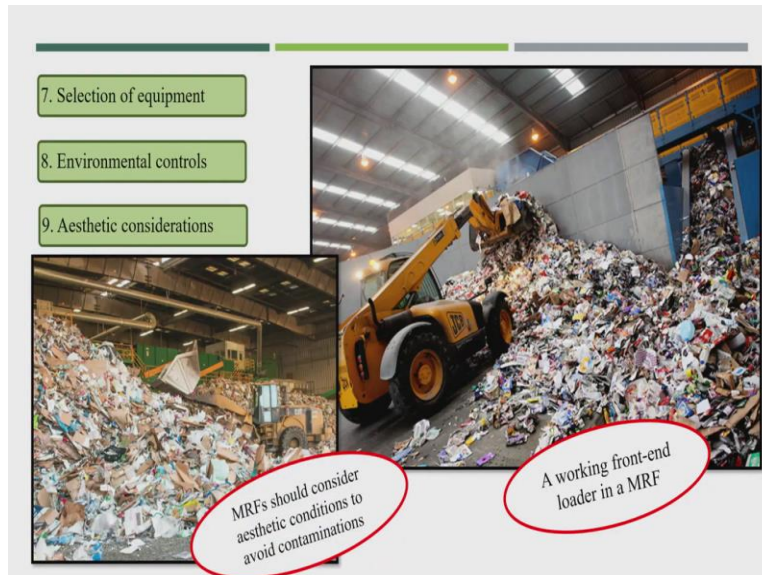
(Refer Slide Time: 33:51)



Then the development of separation process flow diagram considering the characterization of waste materials to be proposed material specification and based on the available equipments. We can develop the separation process. Then the determination of process loading rate how many turns could be possible and again based on the available equipment, we can finalize whether that could be possible mechanically or manual process could be possible based on that would can determine the loading rate transfer per hour.

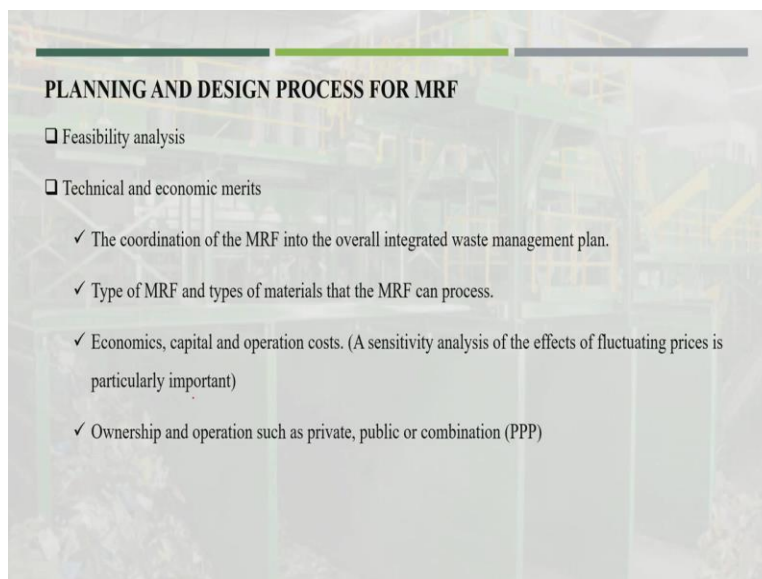
Then once it is finalized and will go for layout design layout and design of physical facilities. We again depend upon waste variable material delivery rates, loading rate and material flow and handling pattern based on that or design will change.

(Refer Slide Time: 34:42)



Then the selection of equipments like already we talked about front end loader what kind of equipments will be required to be seen, in environmental controls, the static control that also need to be see in the MRF station. These are the special engineering considerations for MRF station.

(Refer Slide Time: 35:10)

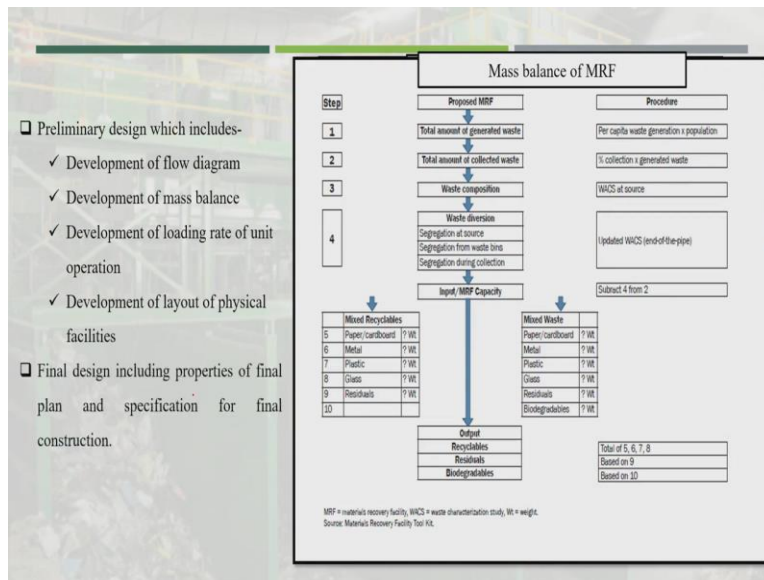


Now once I think we know that what are the different kind of engineering considerations required then we go for planning and designing process for MRF. So in that one first we will do the feasibility study, feasibility analysis. Followed by that we will go for its technical and economical merits. This is the very important on like coordination of MRF into a well integrated waste management plant that is one very important issue technical issue.

Type of MRF, type of material that MRF can process economical capital in operation cost in the specially we need sensitivity analysis for that. and Ownership and operation such as like a possible that only the local authority will do entire work. Like what you see in the Indore is a combined with the local authority along with the rag pickers and one of that New Delhi railway station we saw that they have the operation and work along with some local people Safai Sena and along with that one of the non-profit organization.

So could possible that we can make it with the combination ownership could be possible like we can work in the PPP mode also Public Private Partnership mode also we can work.

(Refer Slide Time: 36:30)

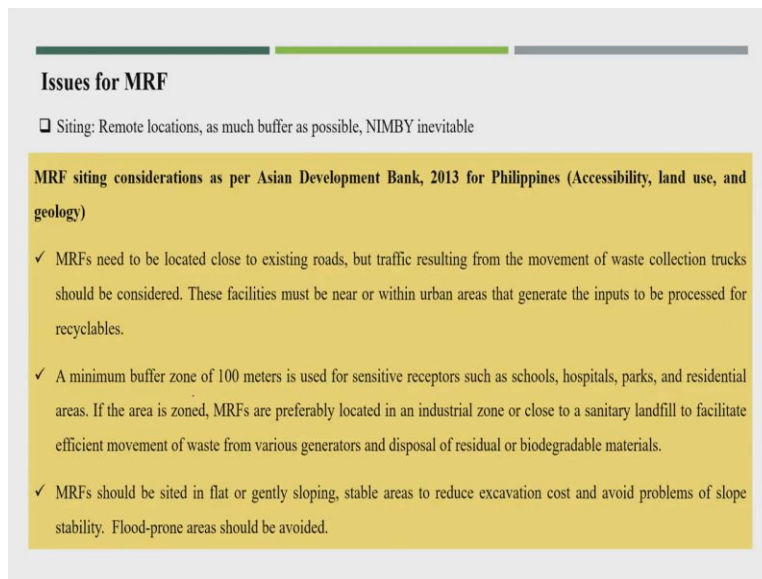


And then once we technically and technical merits will see that then will go for the preliminary design which includes the development of program flow diagram. We can see that like you can see here if the entire waste is commingled waste is reaching, so biodegradable will go different way recyclable matter will go different way so we can see that we can first develop the flow

material then mass balance. This is important. We can get the mass balance how much amount is receiving by the MRF and how much percentage could be possible to get segregated that mass balance has to do.

Then we can finalize the loading rate unit operation then the development of physical facilities. Then final design includes the properties of final plans and specification of final construction.

(Refer Slide Time: 37:32)



Issues for MRF

- ❑ Siting: Remote locations, as much buffer as possible, NIMBY inevitable

MRF siting considerations as per Asian Development Bank, 2013 for Philippines (Accessibility, land use, and geology)

- ✓ MRFs need to be located close to existing roads, but traffic resulting from the movement of waste collection trucks should be considered. These facilities must be near or within urban areas that generate the inputs to be processed for recyclables.
- ✓ A minimum buffer zone of 100 meters is used for sensitive receptors such as schools, hospitals, parks, and residential areas. If the area is zoned, MRFs are preferably located in an industrial zone or close to a sanitary landfill to facilitate efficient movement of waste from various generators and disposal of residual or biodegradable materials.
- ✓ MRFs should be sited in flat or gently sloping, stable areas to reduce excavation cost and avoid problems of slope stability. Flood-prone areas should be avoided.

But along with that I think very important issue has to be discussed. I think 2 issues like siting location that is very important. So this MRF could be located in to the remote location such as, as much as buffer is possible. Do you know that in India, NIMBY is already known is not in my backyard? Nobody wants this kind of stations near to their household area near to their residential area. But also need to be very close to the Highways.

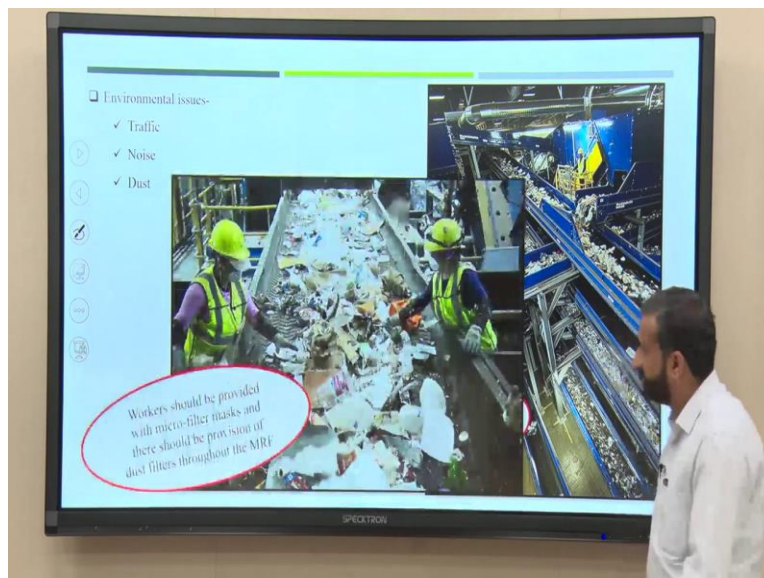
So based on that siting is very important first idea is that people should not be complaint about such location there should not be much objections from the local people. So there are some considerations given by the Asian Development Bank in the 2013 that was given in the Philippines so that we can also used into developing countries like India. So what consideration they proposed that MRF needs to be located close to the existing road.

But traffic resulting from the movement of the waste collection should be considered. The idea was that the close to the existing road but I think traffic as to be and this facility must be near or within the urban areas that generate more amount of waste or more recyclable materials are coming from that particular area. The consideration is that the minimum buffer zone of 100 meter. This is a buffer zone. Ok, 100 meter used for sensitive receptor such as school, hospital, parks are some residential areas.

This MRF stations hundred meter far from this kind of sensitive receptors. If area is zoned, MRF are preferably located in industrial zone. This is also one of the important zone are close to the sanitary landfill to facilitate efficient movement of waste from the various generator and disposal of residual or biodegradable material. Next consideration was MRF should be sited in flat or gently sloping or stable area to reduce excavation cost and avoid problem of slope stability.

So the idea is that because why to pay the necessary money for that if wherever the flat area we are getting it and stable area will be getting it, I think there should not be a flood in such area. There should not be unnecessary excavation is required in such area that kind of location we can finalize. I think these is a very good consideration we can also used in India.

(Refer Slide Time: 40:49)

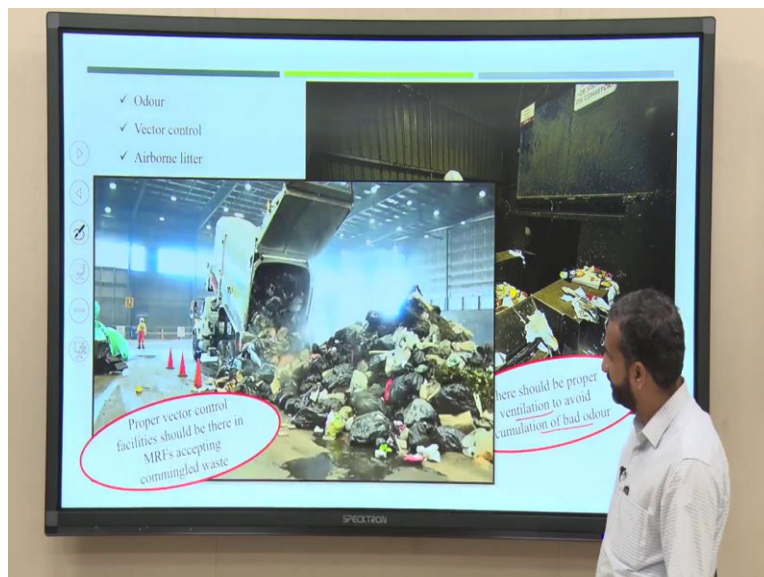


Next is the environmental issue. Environmental issues like traffic because lot of movement of vehicles will be will be there in that particular area so because of that lot of environmental issues

will come up like air pollution issues that need to be seen. Noise lot of noise will come, noise not only by the unit operation in inside MRF stations and also traffic because of lot of transportation; lot of traffic movement in this area.

So the thought is that noise level should be within the permissible limit ok inside the MRF station, and dust obviously a lot of dust will get produce which I talked in one of the lecture also the particulate matter production will be there inside the MRF station. So workers should be provided with proper mask or micro filter mask, and I think whenever they are going inside the MRF station or working along with the wastes, they should have the mask with them. Cleaning facility also is required inside the MRF stations.

(Refer Slide Time: 42:10)



Next is the odor and airborne litter that can be possible also, proper ventilation is required. To avoid the accumulation of bad odor so this is possible when the commingle waste will come to the MRF station. But only the recycling matter will come not to worry about the much odor or airborne litters, vector control, so obviously proper vector control facility should be there. If commingle waste always will come up.

(Refer Slide Time: 42:47)

Public health and safety which include general public and employees

- Employees should have protective clothing, puncture proof gloves, air filters, showers

Economics

- Sensitive to market prices
- Must be environmentally correct or be shut down

environmentally FRIENDLY

Next is the public health and safety which include general public and employee. So employee should be protective clothing puncture proof close air filter, showers ok is required. Proper clothing you can see in this photograph, and proper gloves you can see. Next is the economics so it is very sensitive to market price because whatever the materials are getting segregated that has to be sold then only you can get it some kind of operation cost for running of this MRF station.

So it is very highly sensitive to the market price. And must be environmentally correct or to be shut down. So this are very important issues need to be discussed before finalizing the location of MRF station. So, thank you for this and now I think until that in the last two lectures we on properly understood that the dry matter how waste we can segregate and by having the having unit operations inside the MRF stations we are able to segregate material based on the component wise.

So, now all the components are segregated like paper gets segregated separately, plastic got segregated. In plastic also recyclable plastic are segregated properly, combustible plastics are segregated properly along with that some more material like metal, glass, rubber leather this all components are segregated. So the next lecture what I thought of I will give proper technical information about their recycling facilities like simple ones, with the plastic.

Now everyone knows that most of the plastics are recyclable matter. But what are the different technical way, or different ways by which plastic can get recycled. Not only for the production of the new plastic material also could be possible to produce some different kind of product out of that. That I will be talking in the next lecture so that you people can understand how best this material, segregated material is a best is a recyclables or technically the operation how this recyclable operations could be run to produce recyclables matter or some different products we can get it from this kind of station ok. Thank you.