PLASTIC SCRAP TRADING IN INDIA

CHARACTERISING A PLASTIC TRADING CLUSTER
(TIKRI KALAN, DELHI)

School of Architecture, Civil and Environmental Engineering (ENAC)
Environmental Engineering Institute (IIE)
Environmental Sciences and Engineering Section (SSIE)

École Polytechnique Fédérale de Lausanne (EPFL)

MASTER THESIS

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Abstract

Plastic waste is continuously increasing in India, big nets of informal or formal recycling chain started to grow and formed hotspots. In Delhi, plastic recycling is very present and supplied by a trading area called Tikri Kalan. Yet, no details are known about this place. Gathering information about such a trading area could lead to further studies on this very complicated plastic recycling chain and identify hazardous material flowing into it.

This study aims to gain a more detailed understanding of the inner working of Tikri Kalan, with a specific focus on: the organization and operation procedure; the plastic sources, sinks and flows; the financial aspects of plastic scraps trading activity.

In this study, to obtain a better understanding of Tikri Kalan, a literature research was performed which gave general information about the social context and the structure of the recycling chain. Field visits gave specific information on Tikri Kalan through interviews and observations. However, information are mostly assessment based on interviews, and thus variables cannot be verified.

Results obtained shows that Tikri Kalan is composed of three distinct areas of plastic scrap trading. These areas are composed of units organized in formal or informal plots, where materials are stored between two trading operations. Main operation activities are trading, sorting, dismantling and grinding. Every day, around 1 875 tons of plastic scraps are flowing through Tikri Kalan, where 1 818 t going to recycling factories and 57 t going to brick-kilns. In Tikri Kalan, an overall stock of 108 kt, representing 37% of the annual plastic waste production of Delhi, was compute. This trading activity generates 9.17 million Indian rupees (132 000 CHF) daily and employ 10 000 people.

This study discussed how the different results obtained can be connected and compare them with the literature. Results are interpreted according to the context to understand what is the role of Tikri Kalan in the recycling chain. Limitations according to assumptions and uncertainties are explained.

This study then concludes on the methodology used to collect information and explain the difficulties encountered. Improvements are suggested to conduct further studies in Tikri Kalan or in other plastic scrap trading hotspots.
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**Abbreviation**

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>AIKMM</td>
<td>All India Kabadi Mazdoor Mahasangh</td>
</tr>
<tr>
<td>CHF</td>
<td>Confederation Helvetica Franc – Swiss Franc</td>
</tr>
<tr>
<td>CPCB</td>
<td>Central Pollution Control Board</td>
</tr>
<tr>
<td>DDA</td>
<td>Delhi Development Authority</td>
</tr>
<tr>
<td>DPCC</td>
<td>Delhi Pollution Control Board</td>
</tr>
<tr>
<td>DVD</td>
<td>Digital Versatile Disc</td>
</tr>
<tr>
<td>EMPA</td>
<td>Swiss Federal Laboratories for Materials Science and Technology</td>
</tr>
<tr>
<td>EPFL</td>
<td>Swiss Federal Institute of Technology Lausanne</td>
</tr>
<tr>
<td>GDP</td>
<td>Gross Domestic Product</td>
</tr>
<tr>
<td>HDPE</td>
<td>High Density Polyethylene</td>
</tr>
<tr>
<td>HIPS</td>
<td>High Impact Polystyrene</td>
</tr>
<tr>
<td>INR</td>
<td>Indian Rupee (1 INR = 0.0135 EUR; 1 INR = 0.0149 USD)</td>
</tr>
<tr>
<td>NA</td>
<td>Non-Applicable</td>
</tr>
<tr>
<td>NGO</td>
<td>Non-Governmental Organization</td>
</tr>
<tr>
<td>NGT</td>
<td>National Green Tribunal</td>
</tr>
<tr>
<td>LDPE</td>
<td>Low-Density Polyethylene</td>
</tr>
<tr>
<td>LLDPE</td>
<td>Linear Low-Density Polyethylene</td>
</tr>
<tr>
<td>PA</td>
<td>Polyamide</td>
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<td>PE</td>
<td>Polyethylene</td>
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<tr>
<td>PET</td>
<td>Polyethylene Terephthalate</td>
</tr>
<tr>
<td>PP</td>
<td>Polypropylene</td>
</tr>
<tr>
<td>PS</td>
<td>Polystyrene</td>
</tr>
<tr>
<td>PUR</td>
<td>Polyurethane</td>
</tr>
<tr>
<td>PVC</td>
<td>Polyvinyl Chloride</td>
</tr>
</tbody>
</table>
1 Introduction

In India, plastic consumption has increased twice as fast as the Gross Domestic Product over the years 1990 and 2000 (Patel et al., 2005). In 2012 the plastic consumption was estimated of 12 million tons by the Central Pollution Control Board (CPCB) of India. With raising consumption levels, plastic waste generation is also increasing. Information about the quantities of plastic waste generated in India are very difficult to find or assess. For the city of Delhi, plastic waste production could be from 689.5 metric tons per day (CPCB, 2016) to 1 000 metric tons per day (Toxics Link, 2012).

In India, wastes are collected both by the formal and the informal sector (Gill, 2010). Formality is a very complex definition and will not be debated in this study and, according to Ananya Roy, will be defined as: “a state of deregulation, one where the ownership, use, and purpose of land cannot be fixed and mapped according to any prescribed set of regulations or the law”. This definition is relevant for this study, as a formal activity is considered to be recognized and regulated by the government, or, a formal trading area is known to be a place where owners have to pay taxes to the government to be considered as landlords.

According to the “Times of India” of the 800 metric tons plastic waste generated every day, around 750 metric tons reach a landfill (Lalchandani and Akram, 2013). However it is known from Toxics Link and Kaveri Gill works, that large quantities of plastic are collected and sold to the plastic recycling chain. During the years 1986 and 1990 indigenous petrochemical industry was actively promoted by the Indian Government to meet the increasing demand of plastic, previously satisfied through import (Gill, 2010).

Plastic waste generation increasing and promotion of the petrochemical industry combined, lead to an increase of plastic recycling by both formal or informal sector1 (Gill, 2010). According to Toxics Link, an Indian NGO working for environmental justice, there is in Delhi about 7 000 plastic processing units which 3 300 are working with plastic scrap or are involved in plastic recycling. According to Kaveri Gill, “it is estimated that the Indian market for polymers is going to continue growing at a rate of 15–20 per cent over the next decade and will soon comprise the third-largest market in the world, after the United States and China”.

1 Of 60 to 80 per cent by the informal sector (CPCB, 1998).
According to Empa, a place called Tikri Kalan was identified as the main source of plastic scraps for plastic recycling factories and is located at 30 km West from New Delhi, close to the Harayana border (Gasser, 2016). Tikri Kalan was first identified by Kaveri Gill as a place where traders from Old Delhi were forcibly relocated by the Government, due to new urban planning rules for the city of Delhi. Now, Tikri Kalan has been described as an area where plastic trading happens at a massive scale². This study has been conducted to understand how plastic scraps are traded and plan any further studies on this topic.

1.1 Objectives of this Study

The goal of this master thesis was to gain a more detailed understanding of the inner workings of Tikri Kalan, with a specific focus on:

• The organization, operation procedure and relations of different actors in Tikri Kalan
• The plastic sources, sinks and flows in Tikri Kalan.
• The overall gross income generated and value of services provided in Tikri Kalan.

1.2 Definition of Plastic Scraps

In Tikri Kalan, commodities traded are different qualities of plastic scraps. Plastic scraps are pieces of plastic from any kind of resin and can be divided into two large categories, thermoplastics and thermosets. Thermoplastic can be melted and moulded a second time, but thermosets will lose their mechanical properties if they are melted a second time (Plastics Europe, 2016). In the trading sector, plastic scraps are divided into two categories, the recyclable and the non-recyclable fraction. In this thesis, the quality of the plastic scrap refers to the hardness of the material and if it was already recycled. Hard or fresh plastic scraps are considered as good quality, and soft or recycled plastic scraps are considered as low quality.

² Personal communication with Michael Gasser, EMPA, 2016.
1.3 Institutions Involved in this Study

The following institutions who have participated in this study are:

- **EPFL**: this study was done as a master’s thesis in the Environmental Engineering section at the École Polytechnique Fédérale de Lausanne.

- **EMPA**: The Technology and Society Lab at the Swiss Federal Laboratories for Material Science and Technology (EMPA) is part of the consortium implementing the “Sustainable Recycling Industries” Programme\(^3\) supported by the Swiss State Secretariat for Economic Affairs. To support the project, Empa is conducting research into plastic recycling and trading activities in India.

- **Toxics Link**: is a Non-Governmental Organization working for environmental justice and freedom from toxics, that gave support for data collection on field and give a precious expertise on the study.

\(^3\) [www.sustainable-recycling.org](http://www.sustainable-recycling.org)
2 Waste Collection and Transport

In India, waste collection and transport is carried by two entities, the formal and the informal sector. If formal collectors can be observed occasionally with their big trucks, most of the time, wastes are collected by informal collectors. Figure 1 summarize how plastic waste collection occurs in Delhi (Gill, 2010).

There are two kinds of informal collectors, the Chugnewallah or scavenger, and the Kabadiwallah or itinerant buyer (Gill, 2010). Chugnewallahs are people who take wastes from open spaces such as streets or parks and Kabadiwallahs are people who purchase waste from households and private or public institutions (Gill, 2010).

According to Toxics Link and All India Kabadi Mazdoor Mahasangh (AIKMM), along the transport chain, wastes collected by Chugnewallahs or Kabadiwallahs get more and more segregated. This transport is really driven by small trading operations. Chugnewallahs sell their waste to panni dealers and the Kabadiwallahs to kabadi shops. Then these same panni dealers and kabadi shops sell further their waste to a bigger Kabadiwallah, who sells it further to traders.

Wallah means the man and Kabadi the waste, so Kabadiwallah means the man taking care of wastes.

Wastes found in the street are considered dirty as they can be in contact with kitchen wastes or excreta; and purchased wastes are considered clean as they are often already segregated in paper, glass, iron or plastic category.

Figure 1: Plastic waste collection system attached to Tikri Kalan.
3 Sources, Methods and Procedures

3.1 Description of the Approach

This study was carried out through repeated iteration comparing different observations on the field, literature sources and interviews with experts (Toxics Link, AIKMM, EMPA). This iteration process thus continually improved the understanding of Tikri Kalan plastic scrap trading activity.

The first part was done through a literature review. This step can be considered as a top-down approach. For the second part, a stay of ten weeks in Delhi, from March 23 to June 4, was organised. Field visits were a necessity to collect information from the main stakeholders and get closer to reality. Data acquisition is a very long process in India due to the language barrier. For each field trip in Tikri Kalan, an external person was required to translate interviews. This in-situ data collection represents a bottom-up approach. After each field visit the strategy to collect information was updated to target the most relevant information. The third part, was based on a post processing of the collected information back in Switzerland. On the field it was hard to take position on the most relevant and reliable information, due to working conditions and answers kept changing. The goal was to merge in-situ information and try to connect the bottom-up approach with the top-down approach.

In this study, sources refer to the possible ways of collecting information. Methods explain how information sources were used to determine the inner working of Tikri Kalan. Procedures indicate how collected information were put together to obtain results, as well as how collected information were filtered and evaluated.

3.2 Sources

3.2.1 Literature

Literature was used to have a better historical understanding of the whole plastic recycling chain. It provides information on stakeholders, how they are organised, how they operate and what political issues they were facing.

6 Delhi in summer is very hot, more than 40 °C during the day.
Web literature was used to collect demographic and geographic information of the city of Delhi. It provided some additional information on plastic consumption, and the amount of waste generated in Delhi. Much less information on plastic scrap trading was found online. Only a few studies were published on this topic and mainly about working conditions. The use of official and unofficial website was very useful to compare different information.

3.2.2 Semi-structured Interviews

Semi-structured interviews have been conducted either with traders in Tikri Kalan, representative of associations and other experts in the domain.

After 4 visits on the field, it was necessary to structure interviews with the use of questionnaires. It was not possible to send the questionnaires to traders as most of them did not know how to read or write, there were no addresses to send questionnaires, and bothering people in this area could have led to the end of the project by being not allowed anymore to talk with people inside Tikri Kalan. Questionnaires were therefore filled up together with traders to obtain specific and general information to understand Tikri Kalan from the inside.

Three different questionnaires were made, one for each pre-identified area. There were some questions to evaluate the quality of the answers, the answer being already known, and another ones specific to each area see Appendix B p.43.

Adaptation to the situation was the main challenge in leading the interview. People were generally reluctant to share information, that is why in this study traders names were not collected.

3.2.3 Observation

Observation was essential to collect structural information and develop an intuition on the composition and the quantity of material flowing in Tikri Kalan. When it was not possible to ask question or no answers were given, observation was the last tool to collect information.
3.3 Methods

3.3.1 Organization and Operations in Tikri Kalan

To determine the organization of the three pre-identified trading areas in Tikri Kalan, information on geographic location, unit size, number and location of access roads were collected by literature and web-ressources (Google Earth). Semi-structured interviews gave information on when traders started their activities in the specific area, the different plot sizes, number of units and people involved for each pre-identified area (association leaders, traders). Semi-structured interviews were also used to assess the number of truck scales, maximum bag’s weight and how many people are working. Presence of women or children as well the size and the structure of units were reported through observations.

To determine the operation of the three pre-identified trading areas in Tikri Kalan, information on how people sort and sell plastic scraps as well the different activities that can be found in a plastic scrap trading area were obtained through literature (Gill, 2010; Toxics Link, 2012; Harmaan, 2016). Semi-structured interviews were used to confirm the different activities that can be found within Tikri Kalan and what criteria use people to sort plastic scraps (traders). Semi-structured interviews were also used to determine; how and when plastic scraps that come into the system are distributed between the traders, the opening time of each of the pre-identified area, what are the different unit’s activities and issues on the operation during the monsoon. Observations gave an understanding on how people sort or handle plastic scraps, and how trucks are loaded or unloaded.

3.3.2 Material Flow Assessment of Tikri Kalan

To proceed to a material flow assessment of the three pre-identified trading areas in Tikri Kalan, information on; quantities of plastic waste generated in Delhi, as well the different source of plastic and location of the recycling factories were obtained by literature (DPCC, 2016; Gill, 2010; Toxics Link, 2012). Semi-structured interviews were conducted to get a rough estimation on inflows and figure out what are the different categories of materials (expert, traders). Informal talks with experts were used to understand and describe the flow within Tikri Kalan. Semi-structured interviews gave information on truck capacities, the range of waste coming into each area and what happens to material downstream. Semi-structured
interviews were also used to figure if traders are making stocks, where plastic scraps are sold and what is the percentage of non-recyclable. Average stack height of the plastic scrap piles and the different categories of plastic scrap sources were obtained through observation.

3.3.3 The Economy of Tikri Kalan

To proceed to a financial analysis of the three pre-identified trading areas in Tikri Kalan, information on; items price, traders margins, workers wage and parameters that influence material prices were collected. Semi-structured interviews with traders and experts were conducted to get traders margins, as well information on items price, workers wage and parameters that influence material prices.

3.4 Procedures

3.4.1 Organization and Operations in Tikri Kalan

To understand how plastic scrap trading is occurring in Tikri Kalan an overview explains the main structural characteristics of the three pre-identified areas called PVC market, Choti Tikri and Badi Tikri. Number of units, of people per unit and the area of each market are presented, as well how plastic scraps are flowing through the system.

To understand the organization of each pre-identified plastic scrap trading area, sizes and access roads are reported. Specific information on plot size and allocation process are provided, as well the working structure of the unit and the presence of women or children.

To understand how each pre-identified plastic scrap trading area is operating, observations on the different activities that can be found in each area are reported, and since when they operate. An explanation on how plastic bags are handled is suggested.

In this study, the following definitions are used:

• A place is considered formal if the trader has to pay taxes to operate.

• Two different kinds of traders are defined, specialized and generalist traders. Specialized traders work on 1 to 5 specific resins, or materials of a certain origin (i.e. cable PVC), and generalist traders are working with every kind of resin or materials.
• Sorting is a process where the plastic scrap having the same properties are grouped together. Dismantling is a process where a plastic scrap made of different resin is broken into pieces to further proceed to a sorting process. Grinding is a process where plastic scraps of the same resin are cut or grind into small pieces to reduce the volume of the traded commodity. Stitching is a process where bags are sewed.

• The term resin represents commercial polymers (i.e. HDPE, PVC, LDPE, …).

3.4.2 Material Flow Assessment of Tikri Kalan

In this study, the material flow assessment is divided in three parts. The first one explains the sources of plastic material, the different categories of materials that are traded and stored, and assess the different inflows for the three pre-identified areas. The second one figures what are the sinks and assess the outflows. The third part estimate the stocks in Tikri Kalan and the flows within Tikri Kalan.

As this study is based on an input driven model, information about sources and inflows were collected with all the data collection methods and thus cross-checked. Information about trucks capacity and number of units were collected through semi-structured interviews.

Materials Description

As Tikri Kalan is handling many different kinds of plastic scraps, main categories of interest are reported according to Kabadiwallah’s name with an item examples, the different resin that can be found inside and their bulk density. To obtain the density (mass over volume), a bag of 12 L was filled by plastic scraps of each different categories and weighted with a hand scale.

Inflow Assessment

Results obtained for the inflow are a combination of: assessed values based on the minimum and maximum quantity of plastic scraps coming into each different unit size (medium or big); and the number of trucks coming into one unit according to traders interviews. It was an iterative process to find the best value, as no clear answer were given by traders. To understand in more details how inflows data were collected, it is referred in Appendix C p.47.
To compute the total amount of plastic scrap coming inside the PVC market, the following assumptions, based on observation and interviews with expert, were made:

- there are 350 big units which get a minimum of 3 t/d and a maximum of 6 t/d,
- there are 700 medium units which get a minimum of 1 t/d and a maximum of 2 t/d,
- there are 330 small units which get a minimum of 0.5 t/d and a maximum of 1 t/d.

In Badi Tikri all units seem to be approximately the same size. To compute the total amount of plastic scrap coming inside Badi Tikri, the following assumptions were made:

- the minimum inflow is of 0.15 t/d per unit,
- the maximum inflow is of 0.5 t/d per unit.

To compute the total amount of plastic scrap coming inside Choti Tikri, the following assumptions were made:

- there are 30 big units which get a minimum of 5 t/d and a maximum of 10 t/d,
- there are 50 medium units which get a minimum of 1 t/d and a maximum of 5 t/d.

Inflow for each area was obtained in a range from minimum to maximum. However, to use the software Stan\(^7\) and run the model, it was required to insert the mean value and its related uncertainties\(^8\). For consistency with the model diagram, the selected flows numbers (see Filtering of Collected Information, p.12) are summarized with their mean and uncertainties.

**Sink’s Assessment**

In this study two sinks categories are considered, the plastic recycling industry and brick-kilns (uncontrolled disposal within Tikri Kalan considered as part of the stock assessment). Transfer coefficients were obtained through semi-structured interviews, where questions on the non-recyclable fraction were asked. Then according to traders answers and field observations, non-recyclable fractions were assessed. As two sinks are considered, the fraction going to recycling industry is 100% minus the fraction going to brick-kilns. The related recyclable and non-recyclable fractions are given for all Tikri Kalan trading areas.

\(^7\) Stan: [http://www.stan2web.net](http://www.stan2web.net)
\(^8\) Mean = (maximum + minimum)/2, and uncertainty = ±(maximum - (maximum + minimum)/2)
**Outflows Assessment**

In this study outflows were assumed to be equal to the inflows, as no methods or procedures were found to assess the stock variation. Outflows are obtained by multiplying transfer coefficients with the respective inflows of each pre-identified area.

**Stock assessment**

To estimate stocks in Tikri Kalan, the following relation was established:

\[ S = A \cdot h \cdot R \cdot \rho \]

With:  
- \( S \): stock [kg]  
- \( A \): area \([m^2]\)  
- \( R \): coverage ratio [-]  
- \( \rho \): density \([kg/m^3]\)  
- \( h \): average height of the stack \([m]\)

The coverage ratio was obtain with satellite pictures on Google Earth and observations on the field, it represent the dimensionless density of the plastic scraps bags over the area. The density was estimated with semi-structured interviews. The average stack height assumes piles with an angle of 90° from the ground as plastic scraps are packed into bags.

### 3.4.3 The Economy of Tikri Kalan

**Material category prices**

Material category prices obtained in the field are compared between them to find the range of prices. A standard deviation is also computed to show the variability of prices from one unit to another one.

**Margin**

Margins obtained for PVC market were obtained through personal communications (Imad Ul Riyaz, 2016). Margins obtained for Badi Tikri were obtained through semi-structured interviews with traders. Margins obtained for Choti Tikri were obtained only from two traders. As margins are different for each trader, results are given in an approximative range.

**Wages**

Workers wages were obtained through semi-structured interviews with traders. Results are given for each market according to their organization.
**Overall Gross Income of Tikri Kalan**

To find what is the overall gross income of the plastic scrap trading in Tikri Kalan, an overall margin, for both recyclable and non-recyclable plastic scraps, is assessed and multiplied by the outflows of each market.

\[ \text{Gross income} = \text{Margins}_{\text{fraction}} \cdot \text{Inflow} \]

With the *gross income* in INR/d, the margin in INR/kg and the inflow in kg/d. Margins fraction for recyclable and non-recyclable plastic scraps are assumed to be of 5 and 1.5 INR/kg respectively. The overall gross income of each area is then divided by the number of traders to get average wages for traders.

**Parameters Influencing Plastic Scrap Prices**

Semi-structured interviews were conducted to obtain information on parameters that influence the plastic scraps price in Tikri Kalan. These parameters are looked qualitatively, no information on quantitative price variations were expected from traders.

### 3.4.4 Filtering and Evaluation of Collected Information

Wherever it was possible, the same information was collected repeatedly with several sources and thus cross-checked. For organizational and operational aspects, traders from one area were asked to confirm information collected in another one. For the inflow assessment two main parameters were used to determine if the assessed inflows were realistic or not. On the one hand, inflows were divided by the different truck capacity and like this controlled if the observed truck density in the area was corresponding to observations. On the other hand, inflows were compared to the daily plastic waste production of Delhi obtain through literature\(^9\). If inflows were exceeding more than three times this daily plastic waste production, inflows were considered as wrong. For transfer coefficient, same questions were asked to traders. For the financial aspects, same questions were asked to traders and then compared with literature (Gill, 2010).

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\(^9\) Toxics Link, 2012; Nitin H. Mutha and al., 2005; Shushi Gutpa and al., 1998
4 Results

4.1 Organization and Operation in Tikri Kalan

4.1.1 Overall situation

In Tikri Kalan, three distinct areas of plastic trading were identified and are known under the name of PVC market\textsuperscript{10}, Badi Tikri and Choti Tikri. Illustration 1 shows their location in Tikri Kalan.

\begin{figure}[h]
\centering
\includegraphics[width=\textwidth]{image}
\caption{Location of the 3 trading areas: PVC market in red (1) (28°40'15''N, 76°58'02''E), Badi Tikri in yellow (2) (28°40'34''N, 76°58'10''E) and Choti Tikri in green (3) (28°40'20''N, 76°59'50''E). The area (4) delimited with the blue dotted line represent the ward of Tikri Kalan. The black arrow represent the direction to the centre of Delhi. The pink lines represent the main access roads to the different areas. Source: Google Earth (12.06.2015).}
\end{figure}

The size, the number of units and the number of entry points are given in Table 1\textsuperscript{11}.

\textsuperscript{10} PVC market is just a name and is not related to what kind of plastic scraps can be find inside.

\textsuperscript{11} Results obtained for number of units are good and based on semi-structured interviews with traders (Appendix C). Results obtained for the size and entry points are good and based on satellite pictures (2016).
Table 1: Properties of the 3 markets

<table>
<thead>
<tr>
<th>Area</th>
<th>Size [km²]</th>
<th>Number of units</th>
<th>Number of monthly workers per unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>PVC Market</td>
<td>0.94</td>
<td>1,380</td>
<td>3</td>
</tr>
<tr>
<td>Badi Tikri</td>
<td>0.07</td>
<td>408</td>
<td>4</td>
</tr>
<tr>
<td>Choti Tikri</td>
<td>0.38</td>
<td>80</td>
<td>Non-Applicable (NA)</td>
</tr>
</tbody>
</table>

In these three areas, the main players are traders which import plastic scraps from Kabadiwallahs and export plastic scraps to recycling industries or brick-kilns. PVC market is the biggest trading area, then there is Choti Tikri and finally Badi Tikri.

Usually Kabadiwallahs “push” the material in Tikri Kalan by asking traders if they are interested in some quantity of plastic scraps. Sometimes traders “pull” materials from Kabadiwallahs when they require a specific resin.

PVC market and Choti Tikri get their plastic scraps from Kabadiwallahs located inside or outside Delhi. Badi Tikri gets its plastic scraps only from PVC market. Plastic scraps that are leaving the system are sold, depending on their quality. Good quality plastic scraps are sold to plastic recycling factories, and low quality one go to brick-kilns. Traders can also sell their commodity within traders of Tikri Kalan.

Many bags, heaped into piles, were observed in all the units visited. Littering, from people working or living there, was observed in the surroundings of Tikri Kalan, but is not considered in this study due to its small proportion regarding the quantity of plastic that is traded every day.

12 Then plastic scraps are used as an alternative fuel. Plastic scrap can either be sold or given for free depending on the season (free in Summer).
PVC market is located on the South of the Tikri Kalan ward and is surrounded by a green belt (Illustration 2). There are 3 roads to access this market and 11 entry points\(^{13}\). The main one, where big trucks are coming, is located on the West. Smaller roads, used by medium and smaller trucks, are located on the North, East and South.

Illustration 2: On the left side, a satellite picture of PVC market. Blue arrows indicate the different entry points (even if they are not visible here due to the scale). The red area represent the planned bus terminal. The blue area represent the planned oxidation pound & effluent treatment. On the right side, a satellite picture of different units. Each white spot represent a plastic bag from 80 to 150 kg. Source: Google Earth (15.06.2015)

Badi Tikri is located on the North-east border of the PVC market. This area is delimited by fields on the western, eastern and southern side, while the north is delimited with the road. There are 2 roads to access Badi Tikri and 6 entry points (Illustration 3). The south entry point is directly connected to the PVC market.

Choti Tikri is located 5 km North-East to the PVC market in a place called Netaji Subash Vihar. The area is delimited by the main road on the North, by a residential area on the West, by an electricity facility on the South and by fields on the East. The entry points are located all around the perimeter (Illustration 4), and easily accessible by big trucks.

---

\(^{13}\) Entry points are defined as big or small roads used to enter inside the plastic scrap trading area.
Illustration 3: Satellite picture of Badi Tikri. The black dotted line delimits the area. Blue arrows represent the entry point to the area. The thick black line represents the scale. Source: Google Earth (15.06.2016)

Illustration 4: Satellite picture of Choti Tikri. The black dotted line represents the delimitation of the area. The blue arrows represent the entry points. The thick black line represents the scale. Source: Google Earth (15.06.2016)
For each market there is an association that represent the traders. These associations are led by one or several men that know how to read and write, what most of the traders do not. The goal of these associations is to be the link between traders and government institutions such as the Delhi Pollution Control Committee.

In Tikri Kalan trucks can be weighted by 150 scales of 10 to 100 tons capacities, located within and all around the trading areas. A lot of space is provided in the surroundings of the trading place for parking trucks.

In Tikri Kalan, trading areas are open from 9 am to 6 pm, 6 days a week (Sunday off) all the year, except during national holidays (1 month). Workers and traders work in the plastic scrap trading sector for about 30 years and usually from 20 to 50 years old (for men and women).

According to all interviewed traders, monsoon has a big impact on the operation of Tikri Kalan and all the activity is reduced, as the commodity became wet and therefore cannot be sold due to a change in the bulk mass, as water can fill cavities inside the bags.

### 4.1.2 Organization

PVC market is a formal trading area of 94 hectares. In June 2016, 1 380 units of various sizes are registered in the PVC association. Units are composed of one trader, one supervisor and 2 to 4 workers. According to the PVC market association, PVC market gives jobs to about roughly 7 000 people\(^{14}\). Units can be open area, shelters, houses or a combination of three of them. Plots are delimited according to a plan (Illustration 5).

In PVC market there are many kinds of traders. Some of them are only trading and other one also proceed to sorting. In some units there are only men, and in some others, women can be observed.

Badi Tikri is an informal area of 7 hectares. In June 2016, 408 units of 84 m\(^2\) in average were registered to the Badi Tikri association. Units are composed of one trader and 2 to 4 workers. Badi Tikri gives jobs to about 1 600 people. Plots are delimited into square areas. All the units are made of plastic and bamboo shelters.

---

\(^{14}\) One trader, one supervisor and around 3 worker per units.
In Badi Tikri, people work on a familial structure. The owner who is also the trader, employs his relatives to dismantle and sort the plastic scrap. It was possible to observe little clusters where a couple of shelters were sorting the same type of material, for instance black PP or PE. In this area there is a bigger proportion of women than in the PVC market, and the presence of children was noticed.

Choti Tikri is an informal area of 38 hectares. According to 6 traders interviewed, there are 80 units of different sizes in Choti Tikri. The plot size seems to be very different from one unit to another, it can be from 1 344 m$^2$ to 5 000 m$^2$ (from satellite observation$^{15}$). Units are composed of one trader, one supervisor and an undefined number of workers. No estimation was done on the number of people involved in Choti Tikri. Units are all surrounded by big walls and closed with a gate. Some of the units are big concrete buildings. In Choti Tikri no women were observed.

### 4.1.3 PVC market Specification

As the PVC market is formal, the area was organised with a plan. This plan divides PVC market into 20 zones of different sizes and activities, from the letter A to the letter T. In these zones, there is trading plots, light industries plots, small shops; and as PVC market is formal, there is also a police station, a petrol station, and a waste water treatment plant (Illustration 5).

Traders can choose between 5 different plot sizes, 25, 50, 124, 300 or 495 m$^2$. Plots are sold according to their size, with a yearly levy of 2.5%. Prices are fixed by the Delhi Development Authority and are given in Table 2.

Table 2: Plot prices and yearly taxes of PVC market$^{16}$.

<table>
<thead>
<tr>
<th>Plot size [m$^2$]</th>
<th>50</th>
<th>125</th>
<th>300</th>
</tr>
</thead>
<tbody>
<tr>
<td>Price [INR]</td>
<td>500 000</td>
<td>2 100 000</td>
<td>5 079 500</td>
</tr>
<tr>
<td>Tax [INR/year]</td>
<td>12 500</td>
<td>52 500</td>
<td>126 988</td>
</tr>
</tbody>
</table>

---

15 Google Earth was used to determine the approximate size of the big and small units in Choti Tikri.

16 100 INR = 1.44 CHF (http://www.ezyv.admin.ch, 26.06.2016)
In reality, the situation is much more complicated than the plan. While traders are supposed to respect the organization of the space by renting a fixed number of plots according to the plan, in reality a trader may rent a 6 plots of 50 m² in a 50 m² plots planned area, and so pay 2 millions INR less than for a standard 300 m² plot. Traders do also tend to spread their commodity in the surroundings of their unit (Illustration 2, right side), making the situation on the ground much more complicated than on the plan. Each trader own one unit which can be made of several plots.

By comparing Illustrations 5 and 2, some contrasts from plans to reality can be observed. For instance, the red area in Illustration 2 is planned to be a bus terminal and night shelters, which now can be considered as plots where plastic scraps are stored in bags. Accordingly, the whole area should be occupied, yet, the number of occupied trading plot is currently (Spring 2016) of 2 375 on the total of 2 740 plots\(^\text{17}\), leaving all the south of PVC market free. The blue area is supposed to be a place to treat the effluent of the PVC market through an oxidation pond, but it was never built\(^\text{18}\).

\(^{17}\) Results obtain by comparing satellite pictures and the map of PVC market (Illustration 5).

\(^{18}\) From 2013 to 2016.
4.1.4 Operation

In Tikri Kalan the following processes were observed: trading, sorting, dismantling and grinding. If PVC market and Badi Tikri started their activity in 2013, Choti Tikri was already in operation for more than 10 years\textsuperscript{19}. Observation on the field shows that PVC market, Badi Tikri and Choti Tikri present some differences concerning their operation activities.

Table 3: Operational differences between the three trading places of Tikri Kalan. Small, medium and large refer to the observation occurrence of the different activities.

<table>
<thead>
<tr>
<th>Area</th>
<th>Sorting</th>
<th>Dismantling</th>
<th>Grinding</th>
</tr>
</thead>
<tbody>
<tr>
<td>PVC market</td>
<td>Medium</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Badi Tikri</td>
<td>Large</td>
<td>Large</td>
<td>None</td>
</tr>
<tr>
<td>Choti Tikri</td>
<td>Small</td>
<td>None</td>
<td>Small</td>
</tr>
</tbody>
</table>

By following a bag from the input to the output, the overall operation processes or steps involved in the plastic scrap trading business are the following:

1. A truck is ordered by one or several traders.
2. The truck arrives in Tikri Kalan and gets weighted by one of the 150 scales.
3. The truck delivers its commodity to the customers.
4. Bags and large plastic scraps are distributed between different customers if so.
5. The truck goes weighting again and gives the difference of weight to the customer.
6. The customer usually transfer the money to the supplier via banking accounts.
7. “Homogenous bags”\textsuperscript{20} are stored in piles, “heterogenous bags”\textsuperscript{21} are sorted and dismantled if needed.
8. Plastic scraps are sold within or outside Tikri Kalan according to the same logic, from step 1 to step 6.

\textsuperscript{19} Since 2002, when Mundka started to operate (Gill, 2010). It can be correlated by Google Earth
\textsuperscript{20} A bag is considered homogenous when plastic scraps contained inside are of the same resin.
\textsuperscript{21} A bag is considered heterogenous when plastic scraps contained inside are of different resins.
**PVC market**

PVC market is mainly focusing on trading and sorting activities. Some traders employ people to sort, others only trade. In this area, materials are sorted according to resin and colour of the plastic scrap. No dismantling or grinding was observed in this area. In this area traders are specialized on 1 to 3 resins. When traders want to get rid of low quality plastic they sell it to Badi Tikri.

**Badi Tikri**

Badi Tikri is mainly involved in dismantling and sorting processes. In this area, workers first break apart the plastic pieces such as toys or automotive part. Then, they sort the plastic scrap according to the use, colour, hardness and resin type. In this area traders are specialized on 2 to 3 different resins or qualities\(^{22}\). When they have some scrap that does not belong to their traded resin, they sell it to another trader inside Badi Tikri.

**Choti Tikri**

In Choti Tikri it was difficult to observe operational activities, units being all surrounded by walls. According to 3 unit owners, the main activity is trading. Semi structured interviews with traders and acoustic observations shown that some units in Choti Tikri are also involved in sorting and grinding activities. In this area, there are both generalist and specialized traders.

Table 4 below resumes the general organization and operation informations in Tikri Kalan.

*Table 4: General Organization and Operation information*

<table>
<thead>
<tr>
<th>Area</th>
<th>No of units</th>
<th>Number of people per unit</th>
<th>Total Number of people par area</th>
</tr>
</thead>
<tbody>
<tr>
<td>PVC market</td>
<td>1 380</td>
<td>5</td>
<td>6 900</td>
</tr>
<tr>
<td>Badi Tikri</td>
<td>408</td>
<td>6</td>
<td>2 448</td>
</tr>
<tr>
<td>Choti Tikri</td>
<td>80</td>
<td>3</td>
<td>240</td>
</tr>
<tr>
<td>Total</td>
<td>1 868</td>
<td>NA</td>
<td>9 588</td>
</tr>
</tbody>
</table>

\(^{22}\) Plastic scrap from the same resin can be of different qualities, see material section p.23.
4.2 Material Flow Assessment of Tikri Kalan

4.2.1 Sources

The origin of plastic material can be very heterogeneous, a general overview representing the most important plastic-containing wastes found in Tikri Kalan is suggested in Table 5.

Table 5: Different categories of source and respective examples.

<table>
<thead>
<tr>
<th>Source of materials</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>Consumer goods</td>
<td>Cosmetics, brush, toys, ready-to-wear, helmets</td>
</tr>
<tr>
<td>Electric Equipment</td>
<td>Wire</td>
</tr>
<tr>
<td>Automotive</td>
<td>Car dashboard, engine pipes, gas tanks, cooler tank</td>
</tr>
<tr>
<td>Packaging</td>
<td>Food packaging, DVD boxes, boxes</td>
</tr>
<tr>
<td>Medical / chemistry</td>
<td>Syringes, Petri dish, titration tubes</td>
</tr>
<tr>
<td>Furniture</td>
<td>Garden chairs, propeller fans, mirror frames</td>
</tr>
</tbody>
</table>
4.2.2 Materials

Plastic scraps are categorized by traders according to the terminology employed by the Kabadiwallahs. Name used by Kabadiwallahs, item examples, approximate density and resin types are given in Table 6 (pictures given in Appendix D p.75).

Table 6: Categories used by the Kabadiwallah to trade their plastic scrap, items examples, according density (see Procedures section p.9) and resin type present within the categories.

<table>
<thead>
<tr>
<th>Kabadi Name</th>
<th>Items</th>
<th>Density [kg/m³]</th>
<th>Resin Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brush</td>
<td>Toothbrush</td>
<td>189</td>
<td>PP + Polyamide</td>
</tr>
<tr>
<td>Condenser</td>
<td>Condenser</td>
<td>530</td>
<td>Oil + metals</td>
</tr>
<tr>
<td>Conduit</td>
<td>Inflexible plastic pipe</td>
<td>NA</td>
<td>PVC</td>
</tr>
<tr>
<td>CP</td>
<td>Car dashboard</td>
<td>NA</td>
<td>PP</td>
</tr>
<tr>
<td>Crystal</td>
<td>Petri dish</td>
<td>113</td>
<td>PS</td>
</tr>
<tr>
<td>Dibba</td>
<td>Plastic can</td>
<td>87</td>
<td>HDPE</td>
</tr>
<tr>
<td>Fibre</td>
<td>Plastic garden chair</td>
<td>NA</td>
<td>PVC + nylon</td>
</tr>
<tr>
<td>HM</td>
<td>Plastic bags</td>
<td>26</td>
<td>PE</td>
</tr>
<tr>
<td>Kadak</td>
<td>Plastic cup</td>
<td>38</td>
<td>HIPS + PS</td>
</tr>
<tr>
<td>LD</td>
<td>Water bag</td>
<td>41</td>
<td>LDPE + LLDPE</td>
</tr>
<tr>
<td>Lylooon</td>
<td>Fan propeller</td>
<td>153</td>
<td>PA</td>
</tr>
<tr>
<td>Milki</td>
<td>White plastic cup</td>
<td>38</td>
<td>HIPS + PS</td>
</tr>
<tr>
<td>PET</td>
<td>PET bottle</td>
<td>121</td>
<td>PET</td>
</tr>
<tr>
<td>PP</td>
<td>Bottle lid</td>
<td>79</td>
<td>PP</td>
</tr>
<tr>
<td>PVC</td>
<td>PVC wire</td>
<td>158</td>
<td>PVC</td>
</tr>
<tr>
<td>Rubber</td>
<td>Shoes sole</td>
<td>248</td>
<td>PUR</td>
</tr>
<tr>
<td>Taar</td>
<td>Electric wire</td>
<td>290</td>
<td>PVC + metals</td>
</tr>
</tbody>
</table>

As described in Table 6, materials that come inside Tikri Kalan are mainly plastic. Sometimes, some metals are also part of the traded material, for instance copper inside electrical wires or screws present in automotive part. Condensers and needles with syringes were only found in one unit. An estimation of these non-plastic items could be around 0.5 to 1% of the total mass of plastic scraps present in Tikri Kalan. Metal parts are sold back to Kabadiwallah, but are not considered relevant for the mass flow assessment as they do not represent a sufficient fraction of the flow which already has high uncertainties.

23 Conduit, CP and fibre were too big to be able to proceed to a measurement.
4.2.3 General flows

The general mass flow assessment diagram computed in Stan\textsuperscript{24} is presented in Figure 3.

\begin{figure}[h]
\centering
\includegraphics[width=\textwidth]{figure3.png}
\caption{Mass Flow Assessment of Tikri Kalan plastic scrap trading areas (made with Stan 2.5).}
\end{figure}

Due to the high heterogeneity of resin and plastic scrap item present in Tikri Kalan, no assessment of particular stream flow based on resin or categories was done. Only general quantities were estimated. Inflows and outflows assessment are given in Table 7.

\textit{Table 7: Inflow and outflows assessment values of Tikri Kalan}

\begin{tabular}{|l|c|c|c|}
\hline
\textbf{Area} & \textbf{Inflow [t/d]} & \textbf{Outflow—Recyclers [t/d]} & \textbf{Outflow—Brick-kilns [t/d]} \\
\hline
PVC market & 1 500 ± 500 & 1 351 ± 500 & 17 ± 6 \\
Badi Tirki & 133 ± 71 & 113 ± 61 & 20 ± 13 \\
Choti Tikri & 375 ± 175 & 354 ± 166 & 21 ± 19 \\
Total & 1 875 ± 530\textsuperscript{25} & 1 818 ± 530 & 57 ± 24 \\
\hline
\end{tabular}

\textsuperscript{24} Stan, \url{http://www.stan2web.net}

\textsuperscript{25} The total inflow considers only PVC market and Choti Tikri inputs (Badi Tikri get input from PVC market).
4.2.4 Inflows

For each trading areas, many different inflows were collected. The following paragraph summarizes the collected data to explain to the reader the complexity of the situation. Inflows and outflows selected are present in Table 7. In Stan, the data set is interpreted as mean value and standard deviation of an assumed normal distribution.

**PVC market**

Using the assumption on the amount of plastic scrap by unit size, the minimum and maximum input for PVC market are of 2 236 t/d and 3 509 t/d\(^{26}\).

Using the results from Table 8, the minimum and maximum input for PVC market are of 1 725 t/d and 27 600 t/d.

Table 8: Information collected among traders to assess the inflow of the PVC market.

<table>
<thead>
<tr>
<th>Result N°</th>
<th>Collected information</th>
<th>Discharge [t/d/trader]</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.1</td>
<td>20 tons per day for 350 units each</td>
<td>20</td>
</tr>
<tr>
<td>1.2</td>
<td>80 tons per month for 350 units each</td>
<td>3.33</td>
</tr>
<tr>
<td>1.3</td>
<td>10 tons per day for one unit</td>
<td>10</td>
</tr>
<tr>
<td>1.4</td>
<td>30 tons per month for one unit</td>
<td>1.25</td>
</tr>
</tbody>
</table>

According to Toxics Link, these estimations remain too high. A more reliable inflow, for PVC market, is at minimum of 1 000 t/d and at maximum of 2 000 t/d, or 1 500 ± 500 t/d as given in Table 7.

**Badi Tikri**

Using the assumption on the amount of plastic scrap by unit size, the minimum and maximum input for PVC market are of 61 t/d and 204 t/d\(^{27}\).

Using the results from Table 9, the minimum and maximum input for Badi Tikri are of 81 t/d and 375 t/d.

\(^{26}\) See methods part p.9.

\(^{27}\) See methods part p.9.
Table 9: Collected information to assess the inflow of Badi Tikri.

<table>
<thead>
<tr>
<th>Result N°</th>
<th>Collected information</th>
<th>Discharge [t/d/trader]</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.1</td>
<td>Badi Tikri receive 25% of PVC market's materials.</td>
<td>0.92</td>
</tr>
<tr>
<td>2.2</td>
<td>8 tons per month for 250 big units each</td>
<td>0.33</td>
</tr>
<tr>
<td>2.3</td>
<td>500 kg per day for 1 unit in good conditions</td>
<td>0.5</td>
</tr>
<tr>
<td>2.4</td>
<td>200 kg per day for 1 unit in medium conditions</td>
<td>0.2</td>
</tr>
<tr>
<td>2.5</td>
<td>150 kg per day for 1 unit in bad conditions</td>
<td>0.15</td>
</tr>
<tr>
<td>2.6</td>
<td>700 kg per week for 1 unit in bad conditions</td>
<td>0.12</td>
</tr>
</tbody>
</table>

With the agreement of Toxics Link, the most reliable inflow would be from the first assumption, i.e. at least 61 t/d and at maximum 204 t/d, or $133 \pm 71$ t/d as given in Table 7.

**Choti Tikri**

Using the assumption on the amount of plastic scrap by unit size, the minimum and maximum input for PVC market are of 250 t/d and 500 t/d\(^{28}\).

Using the results from Table 10, the minimum and maximum input for Choti Tikri are of 334 t/d and 800 t/d.

Table 10: Collected information to assess the inflow of Choti Tikri.

<table>
<thead>
<tr>
<th>Result N°</th>
<th>Collected information</th>
<th>Discharge [t/d/unit]</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.1</td>
<td>20 tons per day for one unit</td>
<td>20</td>
</tr>
<tr>
<td>3.2</td>
<td>1 tons per day for one unit</td>
<td>1</td>
</tr>
<tr>
<td>3.3</td>
<td>10 tons per day for one unit</td>
<td>10</td>
</tr>
<tr>
<td>3.4</td>
<td>5 tons per day for one unit</td>
<td>5</td>
</tr>
<tr>
<td>3.5</td>
<td>25 tons per month for one unit</td>
<td>4.17</td>
</tr>
<tr>
<td>3.6</td>
<td>30 tons per month for one unit</td>
<td>5</td>
</tr>
</tbody>
</table>

According to observations, the most reliable inflow would be from the first assumption, i.e. at minimum of 200 t/d and at maximum of 550 t/d, or $375 \pm 175$ t/d as given in Table 7.

\(^{28}\) See methods part p.9.
4.2.5 Sinks

According to all traders interviewed, the two major places for plastic recycling industries are Bawana and Narela. Yet according to one trader, there is more than 25 places for plastic recycling. Concerning brick-kilns no straight answers were collected. Some traders were saying that these brick-kilns were located in Haryana, but also elsewhere all around Delhi. The following transfer coefficients for each sink are given in the table below (Table 11):

Table 11: Sinks transfer coefficient for the different trading areas of Tikri Kalan.

<table>
<thead>
<tr>
<th>Area</th>
<th>Sink</th>
<th>Transfer coefficient</th>
</tr>
</thead>
<tbody>
<tr>
<td>PVC market</td>
<td>Recycling industry</td>
<td>88.6–93%</td>
</tr>
<tr>
<td></td>
<td>Badi Tikri</td>
<td>6.12–10.2%</td>
</tr>
<tr>
<td></td>
<td>Brick-kilns</td>
<td>1–1.2%</td>
</tr>
<tr>
<td>Badi Tikri</td>
<td>Recycling industry</td>
<td>80–90%</td>
</tr>
<tr>
<td></td>
<td>Brick-kilns</td>
<td>10–20%</td>
</tr>
<tr>
<td>Choti Tikri</td>
<td>Recycling industry</td>
<td>90–99%</td>
</tr>
<tr>
<td></td>
<td>Brick-kilns</td>
<td>1–10%</td>
</tr>
<tr>
<td>Tikri Kalan</td>
<td>Recycling industry</td>
<td>95.8–97.6%</td>
</tr>
<tr>
<td></td>
<td>Brick-kilns</td>
<td>2.4–4.2%</td>
</tr>
</tbody>
</table>

**PVC Market**

The transfer coefficient of plastic scraps that are sent to brick-kilns are based on one interview with two traders.²⁹ According to them, the waste production of their unit is about 10 to 12 kg for 1 t. This lead to a ratio of 1% to 1.2% of waste going to brick-kilns. It could be more or less depending on the trader’s activity, but this result seems reliable according to Toxics Link.

The transfer coefficient from PVC market to Badi Tikri was first based on an interview with the PVC association leader. According to him 20% to 30% of plastic scraps coming in PVC market are sent to Badi Tikri. By linking these percentages with the assessed inflow of the PVC market, the average input for Badi Tikri would be of 375 t/d, which is more than Badi Tikri can handle. A percentage of 5% to 15% would be more realistic.

²⁹ It was difficult to obtain of this information, traders were saying they are producing no waste.
Badi Tikri

The transfer coefficient from Badi Tikri to brick-kilns is based on interviews with 8 traders. According to them, the percentage of plastic scraps that are not recyclable was fluctuating from 10% to 20%.

Choti Tikri

The transfer coefficient from Choti Tikri to brick-kilns is based on interviews with 3 traders. According to them, the percentage obtained for the non-recyclable items send to brick-kilns was from 1% to 10%.

4.2.6 Outflows

According to the input driven model computed and transfer coefficients from Table 11, the following outflows are obtained for the different areas of Tikri Kalan (Table 12):

Table 12: Outflows for the different trading areas of Tikri Kalan

<table>
<thead>
<tr>
<th>Area</th>
<th>Sink</th>
<th>Outflows [t/d]</th>
</tr>
</thead>
<tbody>
<tr>
<td>PVC market</td>
<td>Recycling industry</td>
<td>1351 ± 500</td>
</tr>
<tr>
<td></td>
<td>Badi Tikri</td>
<td>133 ± 71</td>
</tr>
<tr>
<td></td>
<td>Brick-kilns</td>
<td>17 ± 6</td>
</tr>
<tr>
<td>Badi Tikri</td>
<td>Recycling industry</td>
<td>113 ± 61</td>
</tr>
<tr>
<td></td>
<td>Brick-kilns</td>
<td>20 ± 13</td>
</tr>
<tr>
<td>Choti Tikri</td>
<td>Recycling industry</td>
<td>354 ± 166</td>
</tr>
<tr>
<td></td>
<td>Brick-kilns</td>
<td>21 ± 19</td>
</tr>
</tbody>
</table>
4.2.7 Stocks

In all the three areas, plastic scraps with the biggest side smaller than 1 m, were stored into big white bags and bigger plastic scraps were tied together with a rope.

Table 13: Surface area, average height of stacks, coverage ratios, density and stocks for each area.

<table>
<thead>
<tr>
<th>Area</th>
<th>Surface area [km²]</th>
<th>Average height of stacks [m]</th>
<th>Coverage ratio [-]</th>
<th>Density [kg/m³]</th>
<th>Stock [t]</th>
</tr>
</thead>
<tbody>
<tr>
<td>PVC market</td>
<td>0.471</td>
<td>1.5</td>
<td>0.75</td>
<td>100</td>
<td>52 988</td>
</tr>
<tr>
<td>Badi Tikri</td>
<td>0.075</td>
<td>1</td>
<td>0.6</td>
<td>60</td>
<td>2 700</td>
</tr>
<tr>
<td>Choti Tikri</td>
<td>0.321</td>
<td>1.7</td>
<td>0.8</td>
<td>120</td>
<td>52 387</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>108 075</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

When comparing stocks (Table 13) with average inflows (Table 7) for each market, the following turnover for PVC market, Badi Tikri and Choti Tikri would be respectively: 35, 20 and 140 days. For PVC market and Badi Tikri, turnovers are reliable according to observations. Traders in PVC market are not able to sell all their commodities at the same time, so an average turnover of 35 days for the whole stock of PVC market is realistic. Traders in Badi Tikri are handling less quantity of material and need to sell on a regular basis to make a livelihood of plastic scrap trading. The turnover in Choti Tikri shows that assessed inflow or outflows are maybe underestimated, as in only two weeks a lot of changes were observed in one unit in Choti Tikri.

4.2.8 Flows within Tikri Kalan

Except for PVC market which is the main supplier of Badi Tikri no significant flows within Tikri Kalan were noticed. According to personal communication, some traders have units both in PVC market and Choti Tikri (Imad Ul Ryiaz, 2016). This allowed them to be registered as a formal unit with a small plot and possess big storage in an informal area which is free of charge. Between Choti Tikri and Badi Tikri no flows were observed. Yet according to one trader, everybody is connected and thus it can happen that some plastic scraps flow between the two areas, but not on a regular basis and in very low quantities.

---

30 It is assumed that the sum of outflows is equal to the inflow.
4.3 The Economy of Tikri Kalan

4.3.1 Material Category Prices

Table 14 gives a summary of selling prices obtained through semi-structured interviews.

*Table 14: Summary of the different material category prices obtained in the field (see Appendix E p.78).*

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Brush</td>
<td>8</td>
<td>40</td>
<td>20.60</td>
<td>13.85</td>
</tr>
<tr>
<td>Condenser</td>
<td>1</td>
<td>10</td>
<td>4.20</td>
<td>3.77</td>
</tr>
<tr>
<td>Conduit</td>
<td>10</td>
<td>20</td>
<td>16.00</td>
<td>4.18</td>
</tr>
<tr>
<td>CP</td>
<td>5</td>
<td>16</td>
<td>12.80</td>
<td>4.66</td>
</tr>
<tr>
<td>Crystal</td>
<td>20</td>
<td>48</td>
<td>28.60</td>
<td>12.64</td>
</tr>
<tr>
<td>Dibba</td>
<td>6</td>
<td>32</td>
<td>17.60</td>
<td>10.14</td>
</tr>
<tr>
<td>Fibre</td>
<td>3</td>
<td>18</td>
<td>7.60</td>
<td>5.94</td>
</tr>
<tr>
<td>HM</td>
<td>0</td>
<td>10</td>
<td>4.25</td>
<td>4.35</td>
</tr>
<tr>
<td>Kadak</td>
<td>1</td>
<td>12</td>
<td>5.80</td>
<td>4.87</td>
</tr>
<tr>
<td>LD</td>
<td>5</td>
<td>60</td>
<td>28.80</td>
<td>21.44</td>
</tr>
<tr>
<td>Lyloon</td>
<td>8</td>
<td>25</td>
<td>13.40</td>
<td>7.02</td>
</tr>
<tr>
<td>Milki</td>
<td>2</td>
<td>12</td>
<td>5.80</td>
<td>3.96</td>
</tr>
<tr>
<td>PP</td>
<td>10</td>
<td>22</td>
<td>13.80</td>
<td>5.22</td>
</tr>
<tr>
<td>PVC</td>
<td>5</td>
<td>15</td>
<td>9.20</td>
<td>4.60</td>
</tr>
<tr>
<td>Rubber</td>
<td>0</td>
<td>2</td>
<td>0.67</td>
<td>1.15</td>
</tr>
<tr>
<td>Taar</td>
<td>2</td>
<td>18</td>
<td>8.50</td>
<td>6.81</td>
</tr>
</tbody>
</table>

Categories price was fluctuating very much from one place to another. Prices are lower in Badi Tikri and bigger in Choti Tikri see Appendix E p.78. The most expensive plastic category is LD which is composed of LDPE. The cheapest are rubber and HM (condenser being not plastic scraps). Trend according to the colour and resin can be identified, i.e. expensive plastic categories, such as Crystal and LD, contain transparent and a single resin.

In Badi Tikri additional information were collected in units specialized on the black PP category. Traders said that they sort black PP in 3 subcategories: low, medium and good quality black PP, which are sold at: 3, 7.5 and 12 INR/kg respectively. Traders also said that sometimes they found valuable material and sell it at 18 INR/kg.
4.3.2  Margins of Traders

According to different interviews with traders and personal communications with Toxics Link staff, the average margin for each market is:

*Table 15: Minimum and maximum traders margin obtained for each area.*

<table>
<thead>
<tr>
<th>Area</th>
<th>Min margin [INR/kg]</th>
<th>Max margin [INR/kg]</th>
</tr>
</thead>
<tbody>
<tr>
<td>PVC market</td>
<td>5</td>
<td>25</td>
</tr>
<tr>
<td>Badi Tikri</td>
<td>0</td>
<td>5.5</td>
</tr>
<tr>
<td>Choti Tikri</td>
<td>0.5</td>
<td>1</td>
</tr>
</tbody>
</table>

In Badi Tikri, all traders interviewed were saying they purchase their plastic scraps at 6.5 INR/kg and sell it at 0 to 3 INR/kg for non-recyclable plastics and from 8 to 12 INR/kg for recyclable plastics. In Choti Tikri, one trader said he was earning 0.5 to 1 INR/kg and another trader said he was selling his commodity from 5 to 30 INR/kg, but did not say at which price he purchased it.

4.3.3  Wages

The different wages were obtained for men and women workers and are given in Table 16.

*Table 16: Different workers wages for each area.*

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>PVC market</td>
<td>8 000 – 12 000</td>
<td>6 000 – 8 000</td>
<td>400 – 500</td>
</tr>
<tr>
<td>Badi Tikri</td>
<td>7 000 – 8 000</td>
<td>5 000 – 6 000</td>
<td>No daily work observed</td>
</tr>
<tr>
<td>Choti Tikri</td>
<td>5 000 – 7 000</td>
<td>No women observed</td>
<td>300 – 400</td>
</tr>
</tbody>
</table>

In PVC market, wages are higher than in Badi Tikri or Choti Tikri. Women are paid to sort plastic scraps and to sew bags. Men are paid to sort, pack plastic scraps and load trucks. External workers are sometimes paid daily to load or unload trucks.

In Badi Tikri, traders were consistent on information given for wages paid to workers. Women are paid to sort plastic scraps and to sew bags. Men are paid to dismantle and sort plastic scraps. No daily workers are present in this area.
In Choti Tikri, daily workers are paid to load or unload trucks. In some units, when a truck needs to be loaded or unloaded, the trader pay 1 000 INR for the job (usually 4 people taking about 3 hours) and workers have to share between them. Monthly workers were not observed, but according to one trader, are employed to sort, grind and pack plastic scraps into bags.

### 4.3.4 Overall Gross Income of Tikri Kalan

Results obtained for the overall gross income of each area and for Tikri Kalan are given in Table 17 according to average outflows from Table 7. The margins used to compute the overall gross incomes are referring to the Procedures section (p.12).

Table 17: Overall gross income generated according to the margin and the outflows.

<table>
<thead>
<tr>
<th>Area</th>
<th>Recyclable [INR/d]</th>
<th>Non-recyclable [INR/d]</th>
<th>Total:</th>
</tr>
</thead>
<tbody>
<tr>
<td>PVC market</td>
<td>6.755·10^6</td>
<td>25 500</td>
<td>6.781·10^6</td>
</tr>
<tr>
<td>Badi Tikri</td>
<td>565·10^3</td>
<td>30 000</td>
<td>595·10^3</td>
</tr>
<tr>
<td>Choti Tikri</td>
<td>1.770·10^6</td>
<td>31 500</td>
<td>1.802·10^6</td>
</tr>
<tr>
<td><strong>Total:</strong></td>
<td><strong>9.090·10^6</strong></td>
<td><strong>87 000</strong></td>
<td><strong>~ 9.2·10^6</strong></td>
</tr>
</tbody>
</table>

Assuming the turnover is the same for each unit, and knowing the number of units and monthly workers per units, it is possible to verify if turnovers of each area provide enough money to pay the workers. Number of units and number of workers are given in Table 1.

In PVC market each unit gets around 5 000 INR/d. If units have around 3 monthly workers in each unit, traders have to spend 1 000 INR/d for labor costs and 4 000 INR/d remains. In Badi Tikri each unit gets around 1 460 INR/d. If units have around 4 monthly workers in each unit, traders have to spend 1 166 INR/d for labor costs and 292 INR/d remains. In Choti Tikri each unit gets around 22 525 INR/d. As no data were available for the number of workers, it is not possible to know labor costs related to the units.
4.3.5 Parameters Influencing Plastic Scraps Prices

Traders could offer very little information on parameters determining plastic scrap prices. The main parameters that influence plastic scrap price were found to be the crude oil price and the season. According to some traders, when the crude oil price is low, prices are low. According one trader in PVC market, due to the oil crisis plastic scrap prices lost 30% of the value.

Some other traders were saying prices are based on the demand which is influenced not only by the crude oil, but also by many other parameters. It was not possible to obtain more information about these parameters, but all traders agreed that there is a big competition between traders.

According to semi-structured interviews in Winter prices are high and in Summer prices are low. In Summer there is more rainfall due to monsoon which slows down all the industry. Instead of selling the non-recyclable plastic scraps to brick-kilns they have to give it for free to get rid of it.
5 Discussion

5.1 Organization and Operation in Tikri Kalan

Results obtained for the organization of the different plastic scrap trading areas of Tikri Kalan are just a snapshot of the situation. The organization of such an activity is constantly changing through the years. Each unit is different one from another, thus results give mainly a perspective on different organizational aspects and characteristics. PVC market, Badi Tikri and Choti Tikri can be differentiated by the number of traders involved and activities operated. PVC market plays the role of the formal plastic scrap trading market and represent the biggest number of traders, whereas Choti Tikri represent a smaller number of traders handling almost the same quantity of materials as the PVC market traders. Badi Tikri is the smallest plastic scrap trading area, but represent the last step to sort the recyclable from the non-recyclable fraction of plastic scraps, and therefore most relevant for the assessment of the recyclable fraction.

Results obtained for the operation represent general guidelines on how traders works. Every unit works slightly differently with a big dependency on the market conditions, especially on the number of workers employed. Informality gives the possibility to traders to operate without paying any taxes or being subject to any environmental rules and therefore maximize their profits. In this sense, it allows the plastic recycling industry to grow faster as no rules or taxes are slowing trading processes. However, informality can expose traders to the closure of their business or even to expropriation (Gill, 2010). This tension led by informality is very much felt on the field. Especially in Choti Tikri, where talking to people or taking pictures is often an issue.

5.2 Material Flow Assessment of Tikri Kalan

Results obtained for materials give a global understanding, on how traders are handling and grouping the different plastic scraps. A lack of identification on the exact resins involved is due the large quantity and variety of plastic scraps that are flowing through Tikri Kalan.

Results obtained for the inflows present big differences from the minimum and maximum values. The assumptions made on the inflows led to uncertainties of, 33%, 53% and 47% for
PVC market, Badi Tikri, and Choti Tikri, respectively. Results obtained for the mass flow assessment and the gross traders income are subject to error, as they are directly linked to the inflow and need to be interpreted with care.

Results obtained for stocks are based on very rough estimations and have to be considered as preliminary assessment. Yet stocks are the core of plastic scrap trading, when the price of plastic scraps is low, traders do not sell their commodity and store it till they are able to make a deal which bring benefits or not too much loss. Traders thus act as a buffer for the plastic recycling industry, and a better understanding of parameters that influence the storage process should be addressed in more details in future studies.

5.3 The Economy of Tikri Kalan

Results obtained for the material prices are found to be very different from one unit to another but remain consistent. According to Kaveri Gill, prices for Crystal after grinding is 40 INR/kg and the obtained values range typically from 20 to 48 INR/kg. As the price obtained by Kaveri Gill comes from grinding units in Mundka, the obtained result seems reliable.\(^{31}\)

Results obtained for the margin represent a good estimation as they provide enough gross income to make the plastic scrap trading sustainable for traders. According to Kaveri Gill, suppliers, here called traders, operate with a net margin from 8% to 10% and earn around 8 750 INR/d of benefits. Even if these results are bigger than what was calculated for PVC market and Badi Tikri, results remains consistent as Kaveri Gill obtained the values around 2009, when crude oil price was lower (Statista, 2016).\(^{32}\) By considering the Indian rupees lost 35% of the value, the new net income of traders would be of 5 688 INR/d, which is not too far from what was calculated for PVC market (5 000 INR/d). Moreover, gross monthly incomes of PVC market and Badi Tikri are within the range found in literature for large and small scale supplier (Gill, 2010).

Results obtained for the parameters influencing the plastic price were not enough redundant. According to one trader, overall plastic prices lost 30% of the value, which can be corroborated by the average price of Crystal obtained and the one found by Kaveri Gill.

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31 Low price crystal is big plastic scraps contained in bags and high price crystal is grind plastic scraps.

32 According to Statista, it was USD 60.89 in 2009 and USD 34.19 in 2016

33 [www.xe.com](http://www.xe.com) (30.06.2016)
5.4 General Discussion

Comparing results obtained for organization and operation with the gross income of traders, show that assessed inflows and margins make sense, as traders are covering all costs related to their activity. In this study, results for each of the three aspects were considered separately and no iteration was done to force results to be coherent. This shows that results obtained are either a good approximation of the reality, or at least that the used methods and procedures are suited to carry out such a study.

Comparing results obtained for the gross income of traders and the material category prices with the book of Kaveri Gill shows that computed values are very close to information obtained for other places involved in the plastic recycling chain, such as Mundka (Gill, 2010). Considering the lowest values for the inflows (1,375 t/d), the total plastic scraps flowing through Tikri Kalan is still bigger than the maximum estimation for plastic waste production of Delhi (1,000 t/d). This corroborates formal studies saying that plastic scrap trading is happening at least on a national scale (Toxics Link, 2012; Gill, 2010).

This study is missing information on moulding factories and brick-kilns using plastic scraps. Knowing what are the quantities of recycled plastic that is used in moulding factories and how much non-recyclable plastic is used in brick-kilns could corroborate the mass flow assessment. Information on stock variations are missing in this study and is a limitation for the computed mass flow assessment model on Stan. Even if not clearly settled in the goals, this study was not able to carry out a complete mass flow assessment and cannot evaluate any scenarios.

With plastic consumption and plastic waste generation increasing, Tikri Kalan represents, for the recycling industry, a key area where large quantities of plastic can be stored before being further recycled. For Delhi, Tikri Kalan represent an area difficult to control and organize, but also a place that drives plastic scraps outside from the city. For the almost two thousand traders and eight thousand workers, Tikri Kalan represents a livelihood that give them the possibility to live with dignity, while providing a great service to the community.
6 Conclusion

The objective of this study was to understand how Tikri Kalan traders are organized and operate, to proceed to a mass flow assessment, and evaluate the economy of Tikri Kalan. On the field it was observed that these three aspects are tightly interwoven. It was then not possible to focus only on one or two of them and get the full picture of the inner working of Tikri Kalan. Results obtained give a good understanding on how Tikri Kalan is organized, operate, in which quantities plastic scraps are flowing and how much is the overall gross income of the activity. Numbers obtained have to be taken as a first approximation and should be corroborated by further studies.

According to results obtained on the field, plastic scraps trading in Tikri Kalan is a very complex activity with about three thousands of people involved in a total area of 1.4 km². Plastic scrap trading in Tikri Kalan is maybe very organized, but remains opaque. It was difficult to obtain information and a constant feeling of being disturbing traders activity was felt. Two months were not enough to carry out a more detailed research or an enough redundant study to be representative.

To improve units structure characterization, different categories of organization and operation should be settled. To get a better assessment on the quantities that are flowing in Tikri Kalan, a survey should be conducted in every weighting house. To get more details on the different resins that are flowing into Tikri Kalan, bags should be opened and sorted according to resins. To make a better stock assessment, satellites or drones could be used to obtain high-resolution pictures, and then proceed to an image analysis to compute the average height and the coverage ratio of plastic scraps. To obtain more data on the financial aspects, a trust relation should be established with traders associations. Translation if required should be done by two independent persons to be sure to obtain the right answer according to the original question.

Traders were very conscious of the service they provide to the community by driving all the plastic scraps outside of the city, and believe it is a win-win situation if the government let them operate. Tikri Kalan is connected to the very complex network of plastic recycling, thus having good understanding on how the plastic materials are flowing through the system is critical if there is a willingness to improve processes involved and increase a recycling ratio that is already high.
7 References

7.1 Literature

AIKMM, 2015. Rights for Waste Workers as Service Providers, a comprehensive valuation of Delhi's informal recycling sector

Bernhard Steubing, Heinz Böni, Mathias Schluep, Uca Silva, Christian Ludwig, 2009. Assessing computer waste generation in Chile using material flow analysis


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Jasmin Küng, 2015. Identifying and evaluating plate waste reduction potentials at a Swiss university canteen (Master thesis)


Michael Gasser, 2016. Personal communication.

Mr. Ashwani Kumar, 2013. Existing Situation of Municipal Solid Waste Management in NCT of Delhi, India. ISSN: 2348 4411


Nitin H. Mutha, Martin Patel, V. Premnath, 2005. Plastics materials flow analysis for India

Oliver Cencic and Helmut Rechberger, 2008. Material Flow Analysis with software Stan


Sycom Projects Consultants Pvt. Ltd., 2010. Baseline study on the legal status of the profit making registered entity of the group of informal sector workers

Tata strategic management group, 2014. Potential of plastics industry in northern India with specific focus on plasticulture and food processing, A report on plastic industry


7.2 Web Resources


Google Earth, 2015. Google Earth V 7.1.5.1557 (22.06.2016). Badi Tikri, New Delhi, India.  
28°40'34.16"N, 76°58'9.92"E.

Google Earth, 2015. Google Earth V 7.1.5.1557 (22.06.2016). Choti Tikri, New Delhi, India.  
28°40'58.26"N, 76°59'4.53"E.

Google Earth, 2015. Google Earth V 7.1.5.1557 (22.06.2016). Hiran Kudna, New Delhi, India.  
28°40'23.25"N, 76°59'54.43"E.

Google Earth, 2015. Google Earth V 7.1.5.1557 (22.06.2016). PVC market, New Delhi, India.  
28°40'4.30"N, 76°57'38.97"E.


http://www.xe.com/currencycharts/?from=USD&to=INR&view=5Y.
8 Appendix

Appendix A: Interviews
Appendix B: Questionnaire
Appendix C: Field results
Appendix D: Material pictures
Appendix E: General pictures
### Interviews

<table>
<thead>
<tr>
<th>Person</th>
<th>Institution or Area</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Experts</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Satish Sinha</td>
<td>Toxics Link</td>
<td>Gather information of the overall organization and operation of Tikri Kalan.</td>
</tr>
<tr>
<td>Priti Mahesh</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Imad</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Shashi Bhushan</td>
<td>AIKMM</td>
<td>Collect information on Kabadiwallahs categories.</td>
</tr>
<tr>
<td><strong>Association</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dharampal Bhilware</td>
<td>P.V.C. &amp; Plastic Waste Dealers Association</td>
<td>Gather information on the organization, operation, flows and financial aspects of PVC market.</td>
</tr>
<tr>
<td>Badi Tikri association</td>
<td>Badi Tikri</td>
<td>Gather information on the organisation, operation, flows and financial aspects of Badi Tikri.</td>
</tr>
<tr>
<td><strong>Traders</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>16</td>
<td>PVC market</td>
<td>Collect information about operation, flows and financial aspects.</td>
</tr>
<tr>
<td>17</td>
<td>Badi Tikri</td>
<td>Collect information about organization, operations, flows and financial aspects.</td>
</tr>
<tr>
<td>6</td>
<td>Choti Tikri</td>
<td>Collect information about organization, operations, flows, materials, and financial aspects.</td>
</tr>
</tbody>
</table>
Three questionnaires were written, but only with small differences. First all similar questions are presented, then the questions asked in two areas, and then question specific for each area.

**PVC market, Badi Tikri and Choti Tikri:**

1. What is the maximum bag's weight that can carry the loaders?
   - How do the people weight bags?
2. How many days people are working in the week?
   - How many hours a day?
   - All the year?
   - Do people take holidays?
   - For festival or wedding?
3. How much are paid the workers?
   - How many people have a salary (monthly, none daily basis)?
4. Till how old people are working?
5. How and why the prices go up and down?
6. How did the traders felt the oil crisis?
   - Did it change the price of the plastic scrap?
   - For how much?
7. When the price is low, is there more waste going to brick-kilns?
   - How much more?
8. What happens to the material downstream?
   - They get one more time segregated?
   - They get grind and washed?
   - Is their material that is coming back?
9. Is there the possibility for the customers to contest the quality of the commodity?
   - They can give it back and being a refund?
10. What is the maximum and minimum quantity of waste that usually comes in the PVC market?
• As a ton per week basis?
• As a ton per month basis?

11. What are the different price for these materials?

<table>
<thead>
<tr>
<th>Material</th>
<th>Price [Rs/kg]</th>
<th>Material</th>
<th>Price [Rs/kg]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bhaati</td>
<td></td>
<td>Kadal</td>
<td></td>
</tr>
<tr>
<td>Brush</td>
<td></td>
<td>Kala</td>
<td></td>
</tr>
<tr>
<td>Conduit</td>
<td></td>
<td>Ld</td>
<td></td>
</tr>
<tr>
<td>CP</td>
<td></td>
<td>Loha</td>
<td></td>
</tr>
<tr>
<td>Chaka</td>
<td></td>
<td>Lyloon</td>
<td></td>
</tr>
<tr>
<td>Crystal</td>
<td></td>
<td>Milki</td>
<td></td>
</tr>
<tr>
<td>Condenser</td>
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<tr>
<td>HM</td>
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<td>Taar</td>
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</tbody>
</table>

12. Is there an issue about the monsoon?
• Are the prices going down during that time?

PVC market and Badi Tikri

13. When a truck is coming, is there is a sharing of the commodity between several traders, or is there only one which after resell some bags to other traders?
• They segregate plastic according to weight or to the quality?

14. Are the traders making stocks?
• Are they saving materials for when the price goes up?
• Do they save money for when the price is low?

PVC market and Choti Tikri

15. Is there platform to weight trucks?
• How many?
• Where?
• Capacity?
• Someone counts the trucks?

16. How much can carry a big truck?

**PVC market**

17. Traders pay the order based on the weight?
   • Or they pay for the whole truck?
18. In the PVC market, how the people segregate waste?
    • According to resin or to use?
    • Do the people use the words such as CP, Kadak, Rubber, Dibba, …?
19. I saw a waste water treatment plant in the map, is it working now?

**Badi Tikri**

20. When you get materials, how do you know how much weight there is in the truck?
    • Do you weight the truck or the bags?
    • Where?
    • Is it your trucks?
    • What is the maximum capacity? 1 tons, 2 tons or 5 tons?
    • Someone counts the trucks?
21. You pay the order based on the weight?
    • Or they pay for the whole truck?
    • Do you order the truck alone or with some other people?

**Choti Tikri**

22. Each unit is purchasing one truck or do you share with other traders?
    • Do you pay the truck based on the weight?
23. What is the percentage of non-recyclable?
24. Do you segregate waste or you only do trading?
    • If you segregate, how do you segregate? According to resin or to use?
25. Is there an organisation or association for Choti Tikri?
26. How many people are working here (in Choti Tikri)?
   • How many units?

27. How much do you earn monthly?
C  Field results

1st Visit to the field (29.03.16):

According to Imad (Toxics Link intern), Tikri Kalan is working in basically 3 main areas.

1. The first one is formal and known as the PVC market of Tikri Kalan. It is mainly a trading area.
2. The second one is informal and is located a little bit north of the PVC market. It is mainly a sorting area.
3. The third one is both formal and informal and is located around the east and north borders of the second one. It is mainly a trading area.

Plastics waste are all coming to the first area, the PVC market. It is the traders who order waste to big and trustful Kabadiwallahs. There, the most valuable items are kept by the big traders located in both first and third area. The remaining part of plastic scrap are sold to the sorters located in the second area. There, sorters segregate waste according to their own standards, as they do not know the resin content and the chemical composition of the plastic waste. So they sort waste according to either their colour, hardness, size, shape and function. For instance they will put all together plastics which are black, soft, and coming from vehicles. It is not the same in Mundka, where they are using acetone to determinate if the plastic is made of ABS, or salty water to separate BFR fraction.

Tikri Kalan is really a place where plastics that looks the same are packed together and sold further to grinding and pelletizing factories for the recyclable part, or to brick-kilns for the non-recyclable part.

This trading structures is highly inter-connected. If some of the area or traders are specialized in something, it does not mean that they will only work on a single brand of plastic scrap. Everybody is buying and selling any kind of plastics waste, albeit sometimes they rather work on one they know better. It is all about making money, so there is no limitation.
PVC market map:

- Total surface (google map + map of PVC market): \((600+1120) \times 1088/2 \approx 94 \text{ ha}\)

- The map is divided into 20 areas, from A to T.

<table>
<thead>
<tr>
<th>Area</th>
<th># Plots</th>
<th>Area</th>
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<tr>
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<td>E</td>
<td>192</td>
<td>J</td>
<td>64</td>
<td>O</td>
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<td>T</td>
<td>118</td>
</tr>
</tbody>
</table>

- Each area can be composed of different type of plot. There is the:
  - “A” type plot: \(8.0 \times 15.15 = 124 \text{ SQM}\),
  - “B” type plot: \(5.0 \times 10.0 = 50 \text{ SQM}\),
  - “C” type plot: \(25 \text{ SQM}\),
  - “WH” Ware Housing plot: \(12 \times 25 = 300 \text{ SQM}\),
  - “SLI” Small Light Industries plots: \(12 \times 25 = 300 \text{ SQM}\),
  - “BLI” Big Light Industries plots: \(15 \times 33 = 495 \text{ SQM}\),
  - The shops

- Area composition:
  - A: Shops, Bank office, Motor garages, Petrol pump, night shelter
  - B: 64 “A” type plots + 54 “B” type plots, 2 shops
  - C: 24 “A” type plots + 168 “B” type plots, 3 shops
  - D: 48 “A” type plots + 42 “B” type plots, 3 shops
  - E: 24 “A” type plots + 168 “B” type plots, 2 shops
  - F: 24 “A” type plots + 168 “B” type plots, 1 shops
  - G: 48 “A” type plots + 42 “B” type plots, 3 shops
  - H: 48 “A” type plots + 54 “B” type plots, 2 shops
  - I: 24 “A” type plots + 168 “B” type plots, 2 shops
2nd Visit to the field (07.04.16)

We went to the sorting area with Satish and Priti. This time, we asked how much plastic was coming into the PVC market and how much kg the people in the sorting area were buying.

- PVC market:
  - According to the people in the sorting area the PVC market gets 350 units $\times$ 20 t/d = 7000 t/d for all PVC market. As a truck is about 10 t capacity, it means there should be 700 trucks coming every day to the PVC market, it is way too much!
  - According to the PVC association, there is 350 big units getting 8 trucks of 10 tons capacity each month. It means one unit is dealing 2.6 t/d, or an overall of 933.33 t/d for all the PVC market, meaning there is close to 100 truck per day coming in and out.
  - From all the waste coming, there is between 70-80% clean waste that just need a little segregation and the remaining part which mixed and more dirty waste that have to be segregated.
  - Waste are going to Mundka, Bawana, sorting market
Sorting market:
- In the sorting market they get 8t/month/cap in average. There is 250 units handling waste there. It means one units is dealing with 266.66 kg/d, which seems correct.
- Of those 8 tons of waste weekly, there is 1 ton of waste → giving a ratio of 12.5% of waste going to brick-kilns.
- The sorting market is specialized on black PP scrap trading. There is 3 quality. **Good** (the plastic are hard and seems more pure) → 1st quality, **medium** (already issued from a recycling process) → 2nd quality, and **low** quality (plastic scrap containing different kind of plastic that cannot be separate, such as brush) → 3rd quality.
- The way of segregation is really based on the colour, then the texture – soft / hard – and then the use. For instance automotive parts will be packed together or toy part together.
- The turnover is quite small. It seems they purchase their waste from the PVC market for a price of Rs. 6.5 / kg and sell it around Rs. 8 to 12. Sometimes, they have plastic of really good quality and sell it for Rs. 18 / kg, but it seems that only one time in a month and for a small quantity.
- The units works with a specific costumer, easier to work like that.

Satellites:
- It seems that the satellites surrounding Tikri Kalan are dealing with a lot of waste. The main reason of their existence is that the traders who own them do not have to pay taxes to the government as it is informal areas.
- The estimation are about 1600 t/d for 80 units and 2 trucks coming for each every day.

Kabadiwallahs dictionary:
- **dibba** = plastic boxes
- **dudh** = milk poach
- **gatta** = cupboard
- Hm = plastic bags
- Kadak = plastic cup
- KAGAJ = paper
- Kala = black plastic
- Katta = concrete plastic bag
- Ld = LDPE
- Loha = iron
- Met = carpet
- Milki = milk plastic bags
- PAWWA = beer glass bottle
- pp = PP
- ppc = plastic
- rabar = shoes plastic
- sada = plastic
- sisha = sisha
- tin = metal

- Brick kilns
  - it seems that brick kilns use around 1.2 – 1.5 t/d of plastic waste as alternative fuel.

**3rd Visit to the field (14.04.16)**

- Small Tikri
  - Location: Netaji Subhash Vihar
  - Number of units: 80 (30 big one)
  - Mainly trading with waste coming out of Dehi.
  - Only trading, no sorting
  - Selling to plastic industries: Bawana, Narela, Munka, or to brick kilns (2-10%). Sometimes they sell to the Sorting Area if the waste are not well sorted.
  - Dealing with all kind of plastic. First they buy waste, then they wait to have a big order and prepare a truck with the required specification.
Input: from 1t/d to 10t/d.
Price: 2 → 50 Rs/kg
Work hours: 5 to 9h
Trade ongoing by phone call → based on trust
The people who fill the truck are paid 150 – 200 Rs to fill one truck, which takes around 2 to 3 hours. Then, they go to another location to work on another truck. They earn between 300 to 400 Rs / day.
There is 800 to 1000 people loading trucks.
People understand that they are a very relevant stakeholder in the plastic scrap management. Without them there will be thousand of people with no work and also big issues about illegal dumping.

4th Visit to the field (22.04.16)

According to my last visit of the field and my Skype meeting with Michael I prepared some questions, yet I was not able to ask all of them.

Question asked to a trader in PVC market:

1. How do the traders make their order? How they give the money?
   • Every body is linked together. When a big Kabadiwallah has a large amount of waste and want to make money he will ask traders in TK if there are interested. For that purpose he call the trader, tell him that he has for instance 10t of plastic scrap and ask him if he is interested.
   • If there is material they don't want, they will sell it to Badi Tikri at a rate of 5 Rs/kg, and give less to the Kabadiwallah.
   • When they get the waste, they directly pay the Kabadiwallah by bank deposit (transfer). It is for them the easiest and also cheapest.

2. How much percentage of waste is coming outside Delhi for the PVC market?
   • So it is impossible for them to know in which proportion waste from outer Delhi are coming. It seems that they get waste from all over India and they cannot
confirm that 100% of the plastic waste product in Delhi ends up in the PVC market.

3. How many people are working in the PVC market? How many days in the year?
   - It seems there are 500 owners with for each one a supervisor. Then there are 9,000 people working on a daily basis. It seems too much for me. I have to investigate more about this number.
   - Anyway, according to the old man, there are 1 lack people working in the PVC market.

4. What are the taxes that units have to pay in the PVC market?
   - The owner has first to purchase is land. It is 21 lacks for A type, 50 lacks for B type and 50.8 lack for warehouse type. Then they have to pay yearly a 2.5% fee according to the total price of plots they have.
   - The price is fixed by the Delhi Development Authority (DDA).
   - Those fees are used by the government to pay the maintenance of the roads and other public services such as the police station or the public lightning.
   - Otherwise, all the costs are taken care by the owner, such as the electricity bill for their plot if they are connected to the grid.

5. How many people are working there? People work on a daily basis?
   - C.f. question 3

6. Can the clients give back the bad waste?

7. What happens to the material downstream?

8. How many small and medium units in Badi Tikri?

9. How the government is disturbing the activity?
   - National Green Tribunal case 2002 to close down Mundka because of air pollution when people were burning electric wire to get back copper and aluminium. The case is still running and seems to be a threat to the plastic recycling activity which could lead to the shut down of the PVC market.
10. What is the plastic types in TK & how they are related to plastic production?

• In TK, literally all kinds of plastic are coming. It seems very difficult to relate them to the plastic production. Yet, it seems that the most valuable materials are ending to the recycling chain, meaning that ragpickers and IB will not pick up waste of low quality. Those one will just be dumped around the city.

During this visit I also understand that trading processes between Kabadiwallahs and the traders are closely related to the plastic scrap market's price. Indeed, when I was there, they told me that now price is low, so everybody is keeping their waste waiting that prices go up.

→ need to find what drives this high and low price!

I also estimate the size of big trucks to be: 4x3x10m = 120m3.

Finally, I had a very long discussion with a very important trader in the PVC market. He was shouting that without them Delhi would be struggling under plastic waste and that their activity was not polluting anything. It seems that they still carry this burden of the NGT case. They have the feeling that nobody understands them, which is in a sense right as people do not even know their existence.

5th Visit to the field (29.04.16)

First we saw a weighting place in the front of the PVC market. This one was able to weight trucks till 100 tons. It seems that his unit is weighing around 50 to 60 trucks per day. 80% of them are medium trucks, such as 15 long x 5 height x 4.5 wide feet for an empty weight of 2900 kg and usually carry 1 ton of plastic. The unit is working 24/7 but usually trucks are coming from Monday to Saturday from 8am to 8pm. The watchman take the vehicle number of each vehicle and collect the money or the name of the owner if he has a kind of subscription in the record. Then he sends to his boss the money and the record at the end of the week. The watchman is paid monthly. According to the watchman and we understood that
there is many weighting place all around Tikri Kalan weighting as well 50 to 60 trucks per day, but it is very difficult to know how many.

There are the trucks we saw:

- Big one: 32x12x8 feet → 10x3.6x2.4 meters, empty 11t, fully loaded 25t
  - Volume: 87m³
  - Plastic carrying capacity: 14t
  - Bulk density: 160.92kg/m³

- Medium one: 14x5x4.5 feet → 4.3x1.5x1.4 meters, empty 2900kg, fully loaded 3880kg
  - Volume: 9m³
  - Plastic carrying capacity: 1000kg
  - Bulk density: 111.11kg/m³

- Medium one: 14x5x4.5 feet → 4.3x1.5x1.4 meters, empty 2970kg, fully loaded 3615 kg
  - Volume: 9m³
  - Plastic carrying capacity: 645
  - Bulk density: 71.67kg/m³

- Medium one: 18x6.3x4.5 feet → 5.5x1.9x1.4 meters, empty 3565kg
  - Volume: 14.5m³
  - Plastic carrying capacity:
  - Bulk density:

I tried to get the information according to the survey I made for the PVC market. We first went to the PVC association, but there was a meeting with the director of the PVC market. They were really not willing to share information and are quite bad people, in a political point
of view. They have power and they don't want to talk because of the NGT case. They know there is a lot of money to make with plastic recycling, so that is why they don't want to be disturbed.

Yet, I was able to speak with some people in the PVC market. There were very nice to me and helped me a lot. They even took the form and try to reply to some questions by themselves.

There is the answer I got:

**Form PVC market – C (4 traders):**

1. **Is there platform to weight trucks?** → Yes
   - How many? → assessment from 100 to 150, but very low confident interval
   - Where? → All around Tikri Kalan
   - Capacity? → 40 to 100 tons
   - Someone counts the trucks? → No, but still there is the record, so yes in a sense

2. **How much can carry a big truck?** → according to one driver: 14 tons

3. **What is the maximum bag's weight that can carry the loaders?** → from 70 to 200 kg (but 200 seems too much… Yet, it can be if a bag of 2m³ is full of PVC sheets?)
   - How do the people weight bags? → the use electronic scale of 500 to 1000kg capacity in each house.

4. **When a truck is coming, there is a sharing of the commodity between several traders, or there is only one which after resell some bags to other traders?** → They purchase a truck together
   - They segregate plastic according to weight or to the quality? → And then they share the plastic based on the resin and the weight.

5. **Traders pay the order based on the weight?** → Yes on the weight of the truck. They pay a lonesome amount.
   - Or they pay for the whole truck? → It seems they pay the truck based on the total weight, not weight of each bags separately according to the resin. Trucks may be
6. How many days people are working in the week? → 6/7, from Monday to Saturday.
   • How many hours a day? → 8am to 8pm, 12h/d
   • All the year? → yes
   • Do people take holidays? → only for festival or if they have to leave.
   • For festival or wedding? → yes. There is 15-20 days of festival in India

7. How much are paid the workers? → Monthly and daily basis
   • How many people have a salary (monthly, none daily basis)? → Monthly: 10,000 – 12,000 Rs, and daily: 400 – 500 Rs.

8. Till how old people are working? → People are aged between 25 and 55 year old on the site.

9. How and why the prices go up and down? → All based on the crude oil price.

10. How did the traders felt the oil crisis? → Yes
    • Did it change the price of the plastic scrap? → Yes
    • For how much? → 30% less

11. When the price is low, is there more waste going to brick-kilns? → Yes
    • How much more? → No data, should check with the Sorting market

12. What happens to the material downstream? → No answer… they don't get the question. I guess they don't care.
    • They get one more time segregated? → Probably
    • They get grind and washed? → Probably
    • Is their materials that are coming back? → Very few.

13. Is there the possibility for the customers to contest the quality of the commodity? → Yes
• They can give it back and being a refund?  →  They don't refund, but replace. It happens very not often.

14. What is the maximum and minimum quantity of waste that usually comes in the PVC market?  →  No answer for the whole PVC market, but for one unit:
   • As a ton per week basis?  →  10 – 20t/d
   • As a ton per month basis?  →  70t/week, so 280t/month

15. Are the traders making stocks?  →  Yes all the market is based on this principle
   • Are they saving materials for when the price goes up?  →  Yes, that's the point!
   • Do they save money for when the price is low?  →  They certainly do it.

16. Is there a big competition between the traders?  →  Yes

17. In the PVC market, how the people segregate waste?
   • According to resin or to use?  →  According to resin.
   • Do the people use the words such as CP, Kadak, Rubber, Dibba, …?  →  yes

18. What are the different price for these materials?

<table>
<thead>
<tr>
<th>Material</th>
<th>Price [Rs/kg]</th>
<th>Material</th>
<th>Price [Rs/kg]</th>
</tr>
</thead>
<tbody>
<tr>
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<td>Rubber</td>
<td>??</td>
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<tr>
<td>Fresh</td>
<td>Meaning not recycled material</td>
<td>Sada</td>
<td>Not resin</td>
</tr>
<tr>
<td>HM</td>
<td>10</td>
<td>Taar</td>
<td>18</td>
</tr>
</tbody>
</table>

19. Is there an issue about the monsoon?  →  Yes
• Is the price going down during that time? → Yes, if the material is wet they don’t sell it. Rates are high in the summer, medium in the winter and low in the monsoon.

20. I saw a waste water treatment plant in the map, is it working now? → no answer.

6th Visit to the field (06.05.16)

With Vinod we went to Badi Tikri to talk with people there. We ask many questions about the quantities they handle and the number of units. We also used the survey I made.

It seems that there is 408 known units of around 84m2 each (100 square yard), and 10% more on hire. Each unit has 3 to 4 people working when the market is low. Each unit is specialized into 2 to 4 different resin. If they have some of another one, they sell the scrap between each other.

By good condition, they are able to sell 500kg/unit/day, but in the current situation (bad condition) they sell around 150 to 200kg/unit/day, or per week: 700kg/unit/week.

Through segregation, they produce around 10 to 20% of non-recyclable items which are going to brick-kilns. During the winter, they sell these non-recyclable at ~3Rs/kg and in summer they give it for free because of the low demand. Indeed, brick-kilns are not working during the summer due to the higher probability of rainfall, especially during the monsoon. Indeed, the rain can destroy the production of bricks. It seems that 3 to 4 Tempo (standard truck = 3t of material) are going to brick-kilns per day.

A bag is usually between 50 and 150kg. I saw a skinny guy wear a bag of 97kg on his shoulder. They are quite strong and crazy to work like that.

Badi Tikri starts after the PVC market was in operation, in the year 2013.

Form Badi Tikri – A (4 traders + association):

1. When you get materials, how do you know how much weight there is in the truck?
   • Do you weight the truck or the bags? → they weigh the Tempo. Once when it comes in and then when it goes out.
• Where? → they get their material exclusively from the PVC market
• Is it your trucks? → no, some people hire it and some have old Tempo.
• What is the maximum capacity? 1 tons, 2 tons or 5 tons? → 3t
• Someone counts the trucks? → no
• What is the cost of the purchased material? → 4-5Rs/kg

2. What is the maximum bag’s weight that can carry the loaders? → 150kg
• How do the people weight bags? → with electronic balance

3. You pay the order based on the weight? → Yes
• Or they pay for the whole truck? → no
• Do you order the truck alone or with some other people? → sometimes together

4. When a truck is coming, there is a sharing of the commodity between several traders, or there is only one which after resell some bags to other traders? → Someone is making the order, and then he resell to the other units by taking a small commission.
• They segregate plastic according to weight or to the quality? → According to the resin

5. How many days people are working in the week? → 6 day a week (Sunday holiday)
• How many hours a day? → from 8am to 6pm. They have no electricity, so when there is not enough light they cannot continue to segregate waste
• All the year? → Yes, but stop their activity when it is raining (monsoon)
• Do people take holidays? → for national holidays, festivals
• For festival or wedding? → indie festivals and some Muslim festival, so about 1 month in a year

6. How much are paid the workers? → depends on the work and the gender
• How many people have a salary (monthly, none daily basis)? → they all work with a salary. For men it is around 7,000 to 8,000 Rs/month, and for women: 5,000 to 6,000 Rs/month
7. Till how old people are working? → from 20 to 50 years old

8. How and why the prices go up and down? → it depends on the demand and the crude oil price
   • How decide of the prices? → traders adapt themselves to the market, but they can make the price fluctuate as they handle the stock.

9. How did you feel the oil crisis? → by the reduction of the price.
   • Did it change the price of the plastic scrap? → yes
   • For how much? → about 25% less

10. When the price is low, is there more waste going to brick-kilns? → no, they store the scrap until the price goes higher again
   • How much more?

11. What happens to the material downstream? → they roughly know what happens
   • They get one more time segregated? → yes
   • They get grind and washed? → yes
   • Is there materials that are coming back? → occasionally

12. Is there the possibility for the customers to contest the quality of the commodity? → yes
   • They can give it back and being a refund? → if they made a loan they refund the customer otherwise there is no refund.

13. What is the maximum and minimum quantity of waste that usually comes in goes out the whole sorting area? → depends on the market
   • As a ton per week basis? → 285.6t/week
   • As a ton per month basis? → 1,142.4t/month
14. Are you making stocks? → yes, depending on the market situation
   • Are you saving materials for when the price goes up? → yes
   • Do you save money for when the price is low? → yes/no

15. Is there a big competition between the traders? → yes but small and only in Badi Tikri. They are not competing with the PVC market or Choti Tikri.

16. What are the different price for these materials? → in Rs/kg
   • Black PP first quality: 12
   • Black PP second quality: 10
   • Black PP third quality: 8
   • Non-recyclable: 2-3 in winter, give it for free in summer.

<table>
<thead>
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<tr>
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<td></td>
<td>Kadak</td>
<td>1</td>
</tr>
<tr>
<td>Brush</td>
<td>PP: 10, fiber: 4</td>
<td>Kala</td>
<td></td>
</tr>
<tr>
<td>Conduit</td>
<td>15</td>
<td>Ld</td>
<td>20</td>
</tr>
<tr>
<td>CP</td>
<td>12</td>
<td>Loha</td>
<td></td>
</tr>
<tr>
<td>Chaka</td>
<td></td>
<td>Lyloon</td>
<td>8-10</td>
</tr>
<tr>
<td>Crystal</td>
<td>20</td>
<td>Milki</td>
<td>7</td>
</tr>
<tr>
<td>Condenser</td>
<td>1</td>
<td>PP</td>
<td>10</td>
</tr>
<tr>
<td>Dibba</td>
<td>20</td>
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<td>4-5</td>
</tr>
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<td>Fibre</td>
<td>6</td>
<td>Rubber</td>
<td>waste</td>
</tr>
<tr>
<td>Fresh</td>
<td></td>
<td>Sada</td>
<td></td>
</tr>
<tr>
<td>HM</td>
<td>waste</td>
<td>Taar</td>
<td>8</td>
</tr>
</tbody>
</table>

17. Is there an issue about the monsoon? → yes, they close the units during raining days, as well if the ground is wet.
   • Is the price going down during that time? → they don't sell plastic scrap if they are wet.
We also ask 2 traders in the PVC market to answer the survey:

**Form PVC market – B (2 traders):**

1. **Is there platform to weight trucks? → yes**
   - How many? → 20
   - Where? → in the PVC market
   - Capacity? →
   - Someone counts the trucks? → no, but there is the record

2. **How much can carry a big truck? → 10 to 14 tons**
   - Price for a truck? → 20-25,000 Rs

3. **What is the maximum bag's weight that can carry the loaders? → 50 to 150 kg**
   - How do the people weight bags? → electronic scale

4. **When a truck is coming, is there is a sharing of the commodity between several traders, or there is only one which after resell some bags to other traders? → usually one truck is for several traders. One guy pays the truck & distribute the material to different traders and take a commission.**
   - They segregate plastic according to weight or to the quality? → both

5. **Traders pay the order based on the weight? → and resin, yes**
   - Or they pay for the whole truck? → no. Someone does the interface between the truck and the trader.

6. **How many days people are working in the week? → 6 days a week**
   - How many hours a day? → 8 to 10 hours, from 9am to 6pm
   - All the year? → yes
   - Do people take holidays? → yes, national holidays
   - For festival or wedding? → yes
7. How much are paid the workers? → 8,000 to 10,000 Rs/month
   • How many people have a salary (monthly, none daily basis)? → all that work every day for them (not the truck loaders).

8. Till how old people are working? → 20 to 50 years old

9. How and why the prices go up and down? → all is based on the demand, which depends on many factors. Crude oil is one of them.

10. How did the traders felt the oil crisis? → a bit
    • Did it change the price of the plastic scrap? → yes
    • For how much? → 1 – 2 Rs change

11. When the price is low, is there more waste going to brick-kilns? → no
    • How much more? → no change, but for 1 ton of material, 10 to 12 kg goes to brick-kilns, so a ratio of 1 to 1.2%

12. What happens to the material downstream? → go to Narela, Bawanna
    • They get one more time segregated? → they don't really care
    • They get grind and washed? → they don't care
    • Is their materials that are coming back? → no, if the customer is not happy, then they make a compromise.

13. Is there the possibility for the customers to contest the quality of the commodity? → yes somehow
    • They can give it back and being refunded? → they can find an agreement with the dealer, a sort of compromise about the price, but material is not coming back.

14. What is the maximum and minimum quantity of waste that usually comes in the PVC market? →
    • As a ton per week basis?
    • As a ton per month basis? → 30t for the unit I asked
15. Are the traders making stocks? → no
   • Are they saving materials for when the price goes up? → no because they never know if price will go up or down.
   • Do they save money for when the price is low?

16. Is there a big competition between the traders? → Yes, but only within the PVC market

17. In the PVC market, how the people segregate waste? → in this unit, they are only dealing with PVC cable.
   • According to resin or to use? → resin and use
   • Do the people use the words such as CP, Kadak, Rubber, Dibba, …?

18. What are the different price for these materials?

<table>
<thead>
<tr>
<th>Material</th>
<th>Price [Rs/kg]</th>
<th>Material</th>
<th>Price [Rs/kg]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bhaati</td>
<td>1</td>
<td>Kadak</td>
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</tr>
<tr>
<td>Brush</td>
<td>8</td>
<td>Kala</td>
<td>3</td>
</tr>
<tr>
<td>Conduit</td>
<td>10</td>
<td>Ld</td>
<td>5</td>
</tr>
<tr>
<td>CP</td>
<td>5</td>
<td>Loha iron</td>
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<td>Lyloon</td>
<td>8</td>
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<td>Crystal</td>
<td>20</td>
<td>Milki</td>
<td>2</td>
</tr>
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<td>2</td>
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<td>10</td>
</tr>
<tr>
<td>Dibba</td>
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<td>PVC</td>
<td>5</td>
</tr>
<tr>
<td>Fibre</td>
<td>5</td>
<td>Rubber</td>
<td></td>
</tr>
<tr>
<td>Fresh</td>
<td></td>
<td>Sada</td>
<td></td>
</tr>
<tr>
<td>HM</td>
<td>2</td>
<td>Taar</td>
<td>Wire: 2</td>
</tr>
</tbody>
</table>

19. Is there an issue about the monsoon? → yes, they stop working during raining days
   • Is the price going down during that time? → it seems that the industry go slowly in that period, so yes, price should go down a bit.

20. I saw a waste water treatment plant in the map, is it working now? → for this trader,
the WWTP is closed.

**Form PVC market – A (2 young traders):**
There is 1500 units in PVC market. 1 plot = 1 unit. Their unit is 300sqm (located in the NE corner) → that is not correct if 1 plot = 1 unit… According to their answers and how they were talking, I was not trusting them at all. They said they were in the business for 4 to 5 years.

1. Is there platform to weight trucks?
   - How many?
   - Where?
   - Capacity?
   - Someone counts the trucks?

2. How much can carry a big truck? → Tempo:3-4tons, biggest one: 7tons

3. What is the maximum bag’s weight that can carry the loaders? → 150kg
   - How do the people weight bags?

4. When a truck is coming, there is a sharing of the commodity between several traders, or there is only one which after resell some bags to other traders?
   - They segregate plastic according to weight or to the quality?
     → 4 to 6 people distribute the waste, each person is working on 2-3 resins

5. Traders pay the order based on the weight?
   - Or they pay for the whole truck?
     → according to the resin and the weight

6. How many days people are working in the week? → 7
   - How many hours a day? → 9am to 6pm
   - All the year?
   - Do people take holidays?
• For festival or wedding?

7. How much are paid the workers?
   • How many people have a salary (monthly, none daily basis)? → they have only a stitching lady

8. Till how old people are working? → 18 – 55 years old, people work for 20 years usually

9. How and why the prices go up and down? → in the past based on crude oil, now based on demand, because they said that crude oil is actually high in India.

10. How did the traders felt the oil crisis?
    • Did it change the price of the plastic scrap?
    • For how much?

11. When the price is low, is there more waste going to brick-kilns?
    • How much more?

12. What happens to the material downstream?
    • They get one more time segregated?
    • They get grind and washed?
    • Is their materials that are coming back?

13. Is there the possibility for the customers to contest the quality of the commodity?
    • They can give it back and being refunded?
      → I saw a man who was called as a supplier. I was controlling the quality of the plastics scrap bags using the soaking method. If there was a lot of material sinking, the quality was bad and if a lot were floating it was good. It seems that dealers deal with suppliers which make the connection between the trader and the industry by taking a commission.
14. What is the maximum and minimum quantity of waste that usually comes in the PVC market? → for his own unit: 25 – 30t/d which is 70% less than what they are usually dealing. It cannot be that much!
   • As a ton per week basis?
   • As a ton per month basis?

15. Are the traders making stocks?
   • Are they saving materials for when the price goes up?
   • Do they save money for when the price is low?

16. Is there a big competition between the traders? → yes inside PVC market, but not with Badi or Choti Tikri

17. In the PVC market, how the people segregate waste?
   • According to resin or to use?
   • Do the people use the words such as CP, Kadak, Rubber, Dibba, …?

18. What are the different price for these materials?

<table>
<thead>
<tr>
<th>Material</th>
<th>Price [Rs/kg]</th>
<th>Material</th>
<th>Price [Rs/kg]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bhaati</td>
<td>2-3</td>
<td>Kadal</td>
<td>15</td>
</tr>
<tr>
<td>Brush</td>
<td>20</td>
<td>Kala</td>
<td>15</td>
</tr>
<tr>
<td>Conduit</td>
<td>15-17</td>
<td>Ld</td>
<td>18-20</td>
</tr>
<tr>
<td>CP</td>
<td>15</td>
<td>Loha</td>
<td>10</td>
</tr>
<tr>
<td>Chaka</td>
<td>2</td>
<td>Lyloon</td>
<td>15</td>
</tr>
<tr>
<td>Crystal</td>
<td>20</td>
<td>Milki</td>
<td>Similar to fiber</td>
</tr>
<tr>
<td>Condenser</td>
<td>2</td>
<td>PP</td>
<td>As CP</td>
</tr>
<tr>
<td>Dibba</td>
<td>5-7</td>
<td>PVC</td>
<td>As conduit and brush</td>
</tr>
<tr>
<td>Fibre</td>
<td>2-4</td>
<td>Rubber</td>
<td></td>
</tr>
<tr>
<td>Fresh</td>
<td>2</td>
<td>Sada</td>
<td></td>
</tr>
<tr>
<td>HM</td>
<td>10</td>
<td>Taar</td>
<td></td>
</tr>
</tbody>
</table>

19. Is there an issue about the monsoon? → yes, if raining, there is no business. They wait till it stops raining.
• Is the price going down during that time?

20. I saw a waste water treatment plant in the map, is it working now?

**7th Visit to the field (20.05.16)**

We went with Vinod to Choti Tikri in order to ask questions with the form. We found a very nice man who was willing to talk to us. This was great, because in this area, most of the people there don't like to share information as they are considered as illegal.

**Form Choti Tikri – A (1 trader):**

1. Is there platform to weight trucks? → yes
   - How many? → 150
   - Where? → all around Tikri
   - Capacity? → from 20 to 100t
   - Someone counts the trucks? → no, but there are records for each weighing house

2. How much can carry a big truck? → till 20t, but not sure

3. What is the maximum bag's weight that can carry the loaders? → 150
   - How do the people weight bags? → electronic scale

4. Each unit is purchasing one truck or do you share with other traders? → they purchase one truck and then trade with other people
   - Do you pay the truck based on the weight? → yes, the truck is coming, go to the weighting place, then deliver and go again to the weighting place.

5. How many days people are working in the week? → 6/7, Sunday off
   - How many hours a day? → regular workers from 9am to 6pm
   - How many holidays in a year? → national holidays and festivals = ~4weeks

6. How many people have a salary (monthly, none daily basis)? → no answer
• How much are working on a daily basis? → 4 to 8 people for truck loading. They give 1000Rs for loading a truck.

• How much are paid the workers (monthly and daily basis)? → monthly between 5000 to 7000Rs

7. Till how old people are working? → more than 20 years, from 20 to 45-50 years old

8. How and why prices are going up and down? → depends on the market, on the crude oil and the chemical that are derived from it, monsoon as also a big impact on prices.

9. How did you feel the oil crisis? → high-high, low-low
   • Did it change the price of the plastic scrap? → yes
   • For how much? → no estimation

10. When the price is low, is there more waste going to brick-kilns? → no
    • How much more? → no change

11. Where are the materials going? → Bawana (the closest), Narela, Shahadra, Udyug Nagar, there is more than 25 areas of plastic recycling

12. Is there the possibility for the customers to contest the quality of the commodity? → yes
    • They can give it back and being refunded? → sometimes some materials can come back and they replace or refund. Basically everything is possible, they will try to keep a good relation with the customer.

13. What is the average amount of plastic that come in and goes out? → no limit, sometimes 0 truck sometimes 2 trucks, …

14. What is the percentage of non-recyclable? → ~5%

15. Is there a big competition between the traders? → big competition yes, in Choti Tikri
they are not playing together, they are all trading on their own.

16. Do you segregate waste or you only do trading? → only trading
   • If you segregate, how do you segregate? According to resin or to use? → it goes to Badi Tikri

17. What are the different price for these materials?

<table>
<thead>
<tr>
<th>Material</th>
<th>Price [Rs/kg]</th>
<th>Material</th>
<th>Price [Rs/kg]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brush</td>
<td>30</td>
<td>Kedak</td>
<td>10</td>
</tr>
<tr>
<td>Conduit</td>
<td>20</td>
<td>Ld</td>
<td>40</td>
</tr>
<tr>
<td>CP</td>
<td>15</td>
<td>Lyloon</td>
<td>15</td>
</tr>
<tr>
<td>Crystal</td>
<td>35</td>
<td>Milki</td>
<td>5</td>
</tr>
<tr>
<td>Condenser</td>
<td>6</td>
<td>PP</td>
<td>11</td>
</tr>
<tr>
<td>Dibba</td>
<td>20</td>
<td>PVC</td>
<td>13</td>
</tr>
<tr>
<td>Fibre</td>
<td>6</td>
<td>Rubber</td>
<td>2</td>
</tr>
<tr>
<td>HM</td>
<td>5</td>
<td>Taar</td>
<td>6</td>
</tr>
<tr>
<td>PET</td>
<td>10</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

18. Is there an issue about the monsoon? → yes
   • Is the price going down during that time? → going down

19. Is there an organisation or association for Choti Tikri? → Yes, Pablu Choan, which is leading the plastic trading association. There is 2000 people registered from Choti, Badi Tikri and PVC market in it.

20. How many people are working here (in Choti Tikri)? → no estimation…
   • How many units? → maybe 150

21. How much do you earn monthly? → it depends

8th Visit to the field (27.05.16)

With Vinod we went a last time to the field in order to get some missing information about the
margin traders do and the streamlines of materials that are coming in the plastic scrap market.

For that purpose we went to Choti Tikri to the trader that was willing to talk. Even if the information given were most of the time incoherent, especially about the margin, the observation in the field were very useful for my work.

Regarding the margin, I got the following information:

- Margin depends mostly on the items
- sometimes they do benefit, sometimes they do loss
- they usually get 0.5 to 1 Rs benefit per kg of plastic scrap
- an average margin could be from 3 to 5%

Then I tried to weigh all the plastic scrap categories by using a 12 Liter bag and a hand scale. I also tried to get information on the plastic resin that can be found in each categories.

- Brush: PP + PA $\rightarrow \rho = 189.01 \text{ kg/m}^3$
  - Compatibility issue: PP & PA not compatible
- Condenser: $\rightarrow \rho = 529.65 \text{ kg/m}^3$
- Conduit: PVC
  - Compatible with: PPMA & SAN,
  - Compatible with small contamination: PUR & PC+ABS
  - Limitedly compatible: ABS
- CP: PP
  - Compatible with small contamination: PE
- Crystal: PS
  - Compatible with small contamination: HIPS
- Dibba: HD + HDPE $\rightarrow \rho = 86.95 \text{ kg/m}^3$
- Compatible with PP

- Fibre: garden chairs PVC + fibre
  - Compatible with: PPMA & SAN,
  - Compatible with small contamination: PUR & PC+ABS
  - Limitedly compatible: ABS

- HM: plastic bags PE
  - Compatible with PP

- Kadak: HIPS + PS → ρ = 37.80 kg/m³
  - Compatible with small contamination: HIPS/PS

- LD: LDPE + LLDPE → ρ = 41.16 kg/m³
  - Compatible with PP

- Lyloon: PA
  - Compatible with small contamination: HIPS, PBTP, PETP, PS, PUR

- Milki: HIPS + PS
  - Compatible with small contamination: HIPS/PS

- PP: → ρ = 78.97 kg/m³
  - Compatible with small contamination: PE

- PVC: → ρ = 158.35 kg/m³
  - Compatible with: PPMA & SAN,
  - Compatible with small contamination: PUR & PC+ABS
  - Limitedly compatible: ABS

- Rubber: PUR → ρ = 247.82 kg/m³
  - Compatible with small contamination: HIPS, PBTP, PC, PE, PETP, PMMA, POM,
PP, PS, SAN, PC+ABS, PC+PBTP

- Limitedly compatible: ABS, HIPS, PVC

- Taar: PVC + metals → $\rho = 289.82$ kg/m$^3$

- PET: → $\rho = 121.39$ kg/m$^3$
D  Material pictures

Pictures 1: Brush: toothbrush and comb, bulk density: 189 kg/m³

Pictures 2: Condenser: capacitors, bulk density: 530 kg/m³

Pictures 3: Conduit: PVC pipes, bulk density: unknown

Pictures 4: CP: PP plastic scraps, bulk density: unknown

Pictures 5: Crystal: hard transparent plastic scraps

Pictures 6: Dibba: plastic pots, bulk density: 87 kg/m³

bulk density: 113 kg/m³
Pictures 7: Fibre: plastic containing fibre, bulk density: unknown

Pictures 8: HM: plastic packaging or bags, bulk density: 26 kg/m³

Pictures 9: Kaddak: plastic cup, bulk density: 38 kg/m³

Pictures 10: LD: water poaches, bulk density: 41 kg/m³

Pictures 11: Lyloon: nylon fibre, bulk density: 153 kg/m³

Pictures 12: Milki: transparent plastic cup, bulk density: 38 kg/m³
Pictures 13: PET: mosquito repellent bottle, bulk density: 79 kg/m³
Pictures 14: PP: coloured plastic made of PP, bulk density: 121 kg/m³

Pictures 15: PVC: protection layers of wire, bulk density: 158 kg/m³
Pictures 16: Rubber: plastic shoe soles, bulk density: 248 kg/m³

Pictures 17: Taar: electrical wire, bulk density: 290 kg/m³
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<tr>
<th>Material</th>
<th>Choti Tikri – A</th>
<th>PVC Market – B</th>
<th>PVC Market – A</th>
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<td>78</td>
</tr>
<tr>
<td>Range</td>
<td>78</td>
</tr>
</tbody>
</table>
F General pictures

Pictures 18: New Delhi: Kabadiwallah’s trailer.


Pictures 20: New Delhi: a municipal solid waste collection point.

Pictures 21: Tikri Kalan: weighing house - maximum truck capacity: 100 tons.

Pictures 22: Badi Tikri: sorting unit: on the left recyclable items, on the right non-recyclable items.

Pictures 23: Badi Tikri: piles of bags stored outside the sorting units.
Pictures 24: Badi Tikri: piles of small plastic wheels and other black automotive parts.

Pictures 25: Badi Tikri: piles of clean bumpers and helmets.

Pictures 26: Badi Tikri: Children playing around the units with plastic scraps.

Pictures 27: Badi Tikri: Non-recyclable plastics going to brick-kilns.

Pictures 28: Badi Tikri: Kabadiwallah’s bicycle to carry small amount of plastic scraps.

Pictures 29: Choti Tikri: Truck (Tempo) full of plastic scrap bags, and behind the closed unit.
Pictures 30: Choti Tikri: inside of one unit.  Pictures 31: Choti Tikri: scale to weigh bags.


Pictures 34: Choti Tikri: bags full of catheters.  Pictures 35: Choti Tikri: garden chairs stack.
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Chemin de la Redoute 10
1197 Prangins
+41 79 575 32 31
kroiss.daniel@gmail.com
Born on the 26th of May 1990, 28 years old

<table>
<thead>
<tr>
<th>Expertise</th>
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<tr>
<td>Specific knowledge</td>
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<td>Good adaptation to an organization or a new</td>
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<td>Programming: Matlab/Octave, Java,</td>
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EDUCATION
Master in Environmental Science and Engineering
Bachelor in Environmental Science and Engineering
Applied physics and mathematics

PROFESSIONAL EXPERIENCE
2014                              Internship at Eawag (3.5 months): MOOC production for Sandec
department and analysis of a DEWATS in Nepal
Skills acquired: teamwork, autonomy, creativity

2013                              Military service (6 months): exploration soldier at ER inf 5
Skills acquired: tenacity, teamwork, promptness

CULTURAL EXPERIENCE
Traveled extensively              Europe, USA, Asia, Africa
Skills acquired: resourcefulness, sensitivity to the environment and human beings, good adaptability

LINGUISTIC KNOWLEDGE
French                            Mother tongue
English                           Level B1-2 (good understanding and conversational ability)

INTERESTS AND HOBBIES
Sports: hiking (Nepal), Ju-jitsu (blue belt), Judo (green belt), handball, running, cycling, sailing, angling.
Practical activities: botanical (flowers, fruits and vegetables), do-it-yourself (mechanics, carpentry, electricity, plumbing).