Data Article

Standardized method for material flow data collection at city level

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\section*{ABSTRACT}

The collection of material flow data is the first step in the evaluation of the circular economy performance and material metabolism at the city level. However, Chinese statistical data are published by Chinese National Bureau of Statistics, and provincial and municipal Bureau of Statistics. This resulted in data being scattered in dispersed sources and varying between cities, even brings about mistakes. Therefore, we established a standardized data collection and accounting method with regular data sources for Chinese cities. In this data collection method, material flow accounting mainly consists of three parts: direct material input, material recycling, and waste disposal. It covers four types of materials, including fossil fuels, biomass, metal minerals, and non-metallic minerals with 155 items. We combined the data sources for the material flow accounting within a standardized Excel spreadsheet with detailed information on statistical data sources and equations to convert the information into material flow data. The statistical data were derived from the China City Statistical Yearbook, the provincial Statistic Yearbook, and the city's statistical yearbook. The estimated data in the material accounting were obtained by converting statistical data using relative coefficients. According to the main sources and features of materials use, the intersectoral

\begin{thebibliography}{99}

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Specifications Table

| Subject | Environmental Science: Ecological Modeling, Management, Monitoring, Policy, and Law |
|---------|----------------------------------------------------------------------------------|
| Specific subject area | Material flow analysis, urban metabolism, Circular Economy, ecological network analysis |
| Type of data | Table |
| How data were acquired | Chinese statistical data are generally published by Chinese National Bureau of Statistics, and the more detailed provincial and municipal statistical data are released by local Bureau of Statistics. The main data sources in the standardized data collections are China City Statistical Yearbook, Provincial Statistical Yearbook, and City Statistical Yearbooks. Most of electronic yearbooks can be acquired on CNKI and some need to purchase. Some of electronic yearbooks are free accessed on the website of bureau of Statistics. |
| Data format | Raw, Analyzed |
| Parameters for data collection | The material flow dataset comprises of three parts (material input, material recycling, and waste disposal) that covers four main material categories (fossil fuel, metal ores, non-metallic minerals, and biomass) and 155 items for the intersectoral material flows between nine sectors (Internal Environment, Agriculture, Mining, Energy Conversion, Manufacturing, Recycling, Household, Construction, and Transportation). Due to inconsistent physical units of raw statistical data, conversion factors are used to transform the raw data into the unified physical unit ‘ton.’ The equations and required statistical data sources for the estimated data are listed in the guide of the material accounting. |
| Description of data collection | The raw statistical data of the urban material flows sourced from the China City Statistical Yearbook, the Provincial Statistical Yearbook, and the Statistical Yearbooks of the City. Taking 16 cities from the Province of Shandong as example for a demonstration and following the standard data collection guide, material flows from the raw data were collected and the estimates were calculated based on the statistical data and equations. All the inconsistent physical unit data were converted into physical mass ton using conversion factors. Finally, urban material flows in unified physical mass were produced. |
| Data source location | Institution: Chinese National Bureau of Statistics, https://data.stats.gov.cn/easyquery.htm?cn=C01 Shandong Provincial Bureau of Statistics, http://tjj.shandong.gov.cn/col/col6279/index.html City Bureau of Statistics: Binzhou Municipal Bureau of Statistics, http://tj.binzhou.gov.cn/tjxx/class?724.html Jinan Municipal Bureau of Statistics, http://tjj.jinan.gov.cn/doc6793/index.html Dezhou Municipal Bureau of Statistics, http://dztj.dezhou.gov.cn/n3100530/n38260319/index.html Dongying Municipal Bureau of Statistics, http://dytj.dongying.gov.cn/doc36583/index.html Weihai Municipal Bureau of Statistics, http://tjj.weihai.gov.cn/col/col13261/index.html Taian Municipal Bureau of Statistics, http://tjj.taian.gov.cn/col/col6886/index.html Linyi Municipal Bureau of Statistics, http://tjj.linyi.gov.cn/sj1/ndsj.htm Zibo Municipal Bureau of Statistics, http://tjzibo.gov.cn/doc886/index.html Jinan Municipal Bureau of Statistics, http://tjj.jinan.gov.cn/col/18279/index.html Qingdao Municipal Bureau of Statistics, http://qdtj.qingdao.gov.cn/n28356045/n32561056/n32561073/index.html Yantai Municipal Bureau of Statistics, http://tjj.yantai.gov.cn/doc118/index.html Zaozhuang Municipal Bureau of Statistics, http://ztj.zaozhuang.gov.cn/tjsj/ Heze Municipal Bureau of Statistics, http://hztj.heze.gov.cn/col/17606/index.html Liaocheng Municipal Bureau of Statistics, http://tjj.liaocheng.gov.cn/tjsj/ndsj/ Weifang Municipal Bureau of Statistics, http://tjj.weifang.gov.cn/TJYW/TJSJ/NDSJ/ Rizhao Municipal Bureau of Statistics, http://tjj.rizhao.gov.cn/doc121734/index.html |

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Value of the Data

- Standardized data collection and accounting method for sectoral material flows of Chinese cities is missing but very fundamental to evaluate a city’s circular economy performance, conduct an urban material metabolism analysis and construct an urban ecological network.
- Urban planners who aim to assess the Chinese city’s CE performance or urban material metabolism can be easy to use the template of data collection, and scholars and students can follow the common framework to initiate urban material metabolism study, build a sectoral urban material flows before an urban ecological network analysis or assess the city’s CE performance.
- The standardized dataset of material flow accounting, which organized the scattered data sources and offered conversion factors for estimations, provides a basic and clear guidance in the context of Chinese cities, and help users take the first step of material flow accounting. Moreover, it can also promote the comparable results of the Chinese city’s CE performances and urban material flows in diverse cities.

1. Data Description

All of the data and templates to produce the material flows at city level can be acquired from Gao, Han; Tian, Xin; Zhang, Yan; Shi, Lei; Shi, Feng (2021), “Datasets for the data collection method and examples of the material flows at city level”, Mendeley Data, V4, doi: 10.17632/2grm3z7cb6.4. In the excel file entitled by Method for data collection, the original information for the sectoral level data of material flows can be obtained following the statistical data sources presented in the template of data collection. The definitions of nine sectors (Internal Environment, Agriculture, Mining, Energy Conversion, Manufacturing, Recycling, Household, Construction, and Transportation) are described in Scopes of Sectors. The templated spreadsheet was built to instruct the basic material flow data collection from statistical sources, and the last column in empty can help users to input their material flow data for their study area. Inventory of Conversion Factors lists all the conversion factors used in the sectoral material accounting at city level.

The excel file of Data for the 16 Shandong cities in 2017 demonstrates the process of material flow accounting. First, raw data were acquired according to the data sources specified in the template. The blanks of some terms indicate the data cannot be accessed by statistical sources but need to be estimated based on the statistical data. In data preparation, some original data were simply calculated or repeated to further unify the physical units of original data by conversion factors. For example, as the original statistic for the number of vehicles are recorded by a specific year, not a variation between two years, so the simply calculations were done. Because the specific materials, like steel, aluminum are estimated by the added roads, pipelines and heat devices, some repetitive numbers appear in different terms for further estimations. Then, according to the conversion factors, the data with inconsistent units were converted into physical unit ton and sectoral material flows are presented in the material flow accounting.

Furthermore, the total amounts of material input, material recycling, and waste disposal can be used to evaluate the CE indicators of the cities. In addition, following the pathways (e.g., F35...
is the material flow from sector 3 mining to sector 5 manufacturing), the material flow dataset can be applied to construct the direct flow matrix, which is basic for the calculation of the integral flows in the ecological network.

2. Experimental Design, Materials and Methods

Data collection was divided into three sections (material input, material recycling, and waste disposal), nine sectors in the urban system, four categories of materials, and 155 items. For the input material, the fossil fuels mainly contain raw coal, crude oil, and natural gas. Industrial fuel products include gasoline, diesel, and fuel oil. Electricity and heat are converted into physical quantities of standard coal equivalents. Biomass contains farm crops, fruits, major forestry products, timber, animal husbandry production, and aquatic products. The metal ore and non-metallic minerals contain 28 categories. With regard to the sectoral material flows in construction, the consumptions of steel, cast iron, aluminum, cement, or gravel are estimated based on the growth of the infrastructure (floor space, roads, drainage pipelines, water supply pipelines, and heated devices). As to the sectoral material flows in households, the steel and aluminum consumptions are measured by the corresponding assumed component contents multiplying the numbers of increased refrigerators, washing machines, air conditioners, color TV sets, and computers. The steel and aluminum consumption in transportation are calculated by evaluating the amount of materials used in vehicles and trucks. For recycling material flows which are lack of the latest statistics, scrap rubber, vehicles, electrical and electronic waste products, scrap steel and non-ferrous metals, waste plastic, and paper were estimated on the basis of the provincial recycling data in period of 12th Five-year. In addition, the recycling rate of grain crops was adopted at an average level; kitchen waste, building and demolition waste were estimated by the capacities of the recycling treatment plants and the operation conditions of the plants; four kinds of waste for fuel, residual pressure, and heat for circulated use were also considered as materials recycling. For waste disposal, industrial solid wastes come from the city's statistics; agricultural wastes were estimated by two parts: solid waste from aquacultures and unrecycled crop straws; construction and transportation wastes were measured by the generation minuses the recycling section, respectively.

Based on the standardized methodology for MFA data collection, 16 cities of the Shandong Province were considered in the case study. Raw data from 2017 were collected from the statistical database, and unified material flow was converted using conversion factors [1]. The ready-material flow datasets were used for two main purposes in this case. On one hand, the sectoral material flows were applied to construct the direct flow matrices which served to estimate integral flows in urban sectoral ecological networks [2]. On the other hand, the processed datasets were also applied to evaluate the city's CE indicators from the total amount of material input, recycling, and waste disposal.

Ethics Statement

None.

CRediT Author Statement

Han Gao: Data curation, Software, Visualization, Investigation, and Writing; Xin Tian: Conceptualization, Methodology, Investigation, Supervision, and Writing; Yan Zhang: Methodology and Writing; Lei Shi: Data curation, Methodology and Writing; Feng Shi: Methodology and Writing.
Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that have or could be perceived to have influenced the work reported in this article. There are no conflicts of interest to declare.

Data Availability

Standardized method for material flow data collection at city level (Reference data) (Mendeley Data).

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