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Understanding the mechanism of food waste management by using stakeholder analysis and social network model: An industrial ecology perspective

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ABSTRACT

Household food waste accounts for the largest fraction of municipal solid waste and becomes an emerging issue in the biogeochemical cycle of urban ecosystem. Multiple stakeholders with varied characteristics are involved in the food waste management; moreover, they can throw great impacts on the material flow of urban waste, in an industrial ecology perspective. However, the internal mechanism of food waste recycling and composting, regarding the behavior and interaction of different stakeholders, is not clear in previous studies. In this research, recycling and composting potential of household food waste is studied by applying the methodology of stakeholder analysis and social network model. The interest, attitude, power and knowledge of different stakeholders and their social networks were examined by interviews, with the studied case of Beijing, China. Result shows the significant difference of multiple stakeholders' properties. The governmental department of municipal solid waste management has the highest power and maximum interest on food waste recycling, whereas the key players (both high power and maximum interest) located in the midstream and downstream of food waste recycling (utilization of compost) are lacking. In addition, the stakeholders, who easily collect accurate information on food waste recycling, are also the ones most willing to share the knowledge. However, the knowledge and information of most stakeholders are insufficient and inaccurate. The density, node and centrality of the social networks on food waste recycling and composting indicate that here were inefficient connection or disjoint between downstream stakeholders and up/midstream stakeholders, however the some key nodes, e.g. composting utilization stakeholders (fertilizer plants) and municipal solid waste management service companies, could contribute more to bridge the social networks of food waste management. Using the tools of stakeholder analysis and social network models can help in understanding the internal mechanism and the complexity of the material flows of urban ecosystem.

1. Introduction

With the rapid development of urbanization, municipal solid waste generation has been increasing and has become a major challenge for urban ecosystem management, particularly in over-populated developing countries (Wang and Nie, 2001; Zhang et al., 2010; Wilson et al., 2012). There are 170.81 million tons of municipal solid waste, of which 60% is household food waste, is generated and collected in China in each year (Zhang et al., 2010). Most of foodwaste was disposed into landfills and treated by incinerators, producing large amounts of contaminants and wasting considerable biomass resources (Kuo et al., 2008; Mor et al., 2006). Household food waste contains abundant organic carbon and nutrient and can be used as an ideal material for composting, however, nowadays it waste always contain a lot of non-biodegradable and even hazard fractions due to insufficient source separation of municipal solid waste (Wang and Nie, 2001; Tai et al., 2011), therefore, the value of food waste composting has been lowered. The social economic and environmental factors of food waste management should be concerned, if a clean and sustainable material flow of food waste is expected. Similar to other issues of biogeochemical cycles in urban ecosystem, the food waste management also involves multiple stakeholders, including governments, enter-

Abbreviations: BC, betweenness centrality; CC, closeness centrality; DC, degree centrality; N, node of the social network; SA, stakeholder analysis; SNA, social network analysis.

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prises; scientific research institutes, residents, farmers and so forth, and their behaviors are determined by their interests, attitudes, power and knowledge (Tai et al., 2011; Xu et al., 2015). Previous studies examined a lot of aspects on food waste treatment and management, however, these researches were mainly focused on the technical and policy marking issues (Kim and Kim, 2010; Beattie 2014), few of them discussed about the internal mechanism of different stakeholders in the food waste management system.

Stakeholder analysis (SA) and social network analysis (SNA) models were demonstrated as a useful approach to study the environmental & resource management and public governance issues (Reed et al., 2009; Lienert et al., 2013). SA methodology first emerged as an approach for strategic management in the mid-1980's (Emshoff, 1980; Freeman, 2010). Furthermore, social network analysis model also showed its great potential to examine the behavior and interaction of multiple stakeholders. SNA model was first used to a fishing village in Norway, and the nodes and their relationships, rather than individuals, were emphasized in this study (Barnes, 1954). Harary (1969) improved the model by using the conceptual graph including nodes (points) and relationships(lines) between nodes. In recent years, SNA model were applied to study the natural resource management, such as water governance, marine ecosystem and food chains (Navia et al., 2010; Stein et al., 2011; Buzhdygan et al., 2012; Dell'Apa et al., 2013; Hicks et al., 2013), attempting to integrate this sociological tools into the interdisciplinary researches. In the early stage, the theory was mostly based on manual computations and drawings; in the 1990s, with the development of computer science, a higher visual degree was achieved and the visual matrix was used to portray the entire system network, enabling the studies not only on individual network properties, but also on full social network properties and the network structures. In the past, most studies concentrated on non-direction binary (Hicks et al., 2013; Navia et al., 2010; Yang and Zou, 2014). Currently, attention is turning to the direction of assignment value study (Buzhdygan et al., 2012; Dell'Apa et al., 2013; Lienert et al., 2013). However, only a few of works studied the waste management issues by applying SA and SNA methods. Caniato et al. use this tool to analyze the construction of a medical wasteincineration project (Caniato et al., 2014; Caniato et al., 2015). Xu et al. (2015) studied the issue on community-based source separation by applying SA model, and put forward implications of incentive policies. Xu et al. (2016) studied the stakeholders of a household food waste source separating program, but go into the detail models of different stakeholders. However, more efforts in this field are worthy to be taken, because it is not only valuable for understanding the mechanism and complexity of human dominated urban ecosystem, but also useful for who make policies and implement sustainable waste management programs.

In this research, SA and SNA models are integrated to study the potential of starting up a food waste recycling and composting program in Beijing, China. The interest, power, attitude and knowledge of twenty-three categories of related stakeholders are analyzed by interviews, moreover, a structural social network model containing the nodes, relationship and centrality indicators were established for understanding the mechanism and complexity of food waste management. At last, the policy implications are put forward according to the modelling analysis.

2. Materials and methods

2.1. Stakeholder analysis

SA method follows three steps: 1) identifying stakeholders; 2) categorizing stakeholders; and 3) investigating stakeholders to know their properties (Grimble and Wellard, 1997; Reed et al., 2009). The first interviewees' list of stakeholders was created following suggestions given by the experts in the field of municipal solid waste management, and the interviewees' list was upgraded when more investigations had been done. Finally, twenty-three stakeholders were included in this study (details of the interviewees are shown in Supplementary material, S1); the name, symbol, abbreviation and classification of each stakeholder are shown in Table 1. We classified these stakeholders into five categories according to their social roles, named administration, state-owned enterprise, private enterprise, research institute, social organizations and other types.

For better understanding the food waste material flow in an industrial ecology perspective, we divided the stakeholders into four types according to their position of the industrial chain in the food waste management system. Fig. 1 shows the material flow and the industrial chain of food waste management system, along with the position or impacts of different stakeholders.

The specific profiles for different stakeholders are described as follows:

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a Administration: MCCAE is the major administrative department in charge of the planning, construction, and supervision of waste treatment facilities. CAC is in charge of MSW collecting and instructing source separation in community. DSMO is the superior department of CAC, who communicates with MCCAE about the affairs of waste management. AB and BMBL&F are government department who approve the utilization of final compost products. VMC is the representative of farmers, who are important ultimate users of compost.

b State-owned enterprise: ESEG is a state-owned enterprise closely related to MCCAE. It is responsible for collecting and transporting municipal solid waste to the MSW facilities. The responsibility of CP is biological treatment of the organic waste in Beijing under the building operation transfer mode (BOT); CP is highly relied on the financial subsidies from MCCAE and is governed by ESEG. TV is a state-owned media. It is involved in publicity for compost products around the nation. Enterprises invest in LP, similar to CP, which is attached to ESEG, whose subsidiary is responsible for the operation and supervision of LP.

c Private Enterprise: IP, which is supervised by MCCAE and ESEG, refers to investment and operation in enterprises. FP encompasses those companies that produce organic fertilizer, demand source-sorted food waste, and have the capacity to improve the quality of fertilizer. CFP refers to companies that only provide chemical fertilizers and which are against the production of organic fertilizer. SNB possibly uses final compost products for seedling. LEC is an emerging enterprise focusing on forestry and landscaping construction with most of the engineering projects from BMBL&F. NM is the propagandist for science popularization to raise environmental awareness among the young and middle-aged. MSC refers to emerging enterprises that provide solutions to waste management and establish connections among stakeholders.

d Research institute: MR concentrates on current planning and policy and aims at identifying proper solutions through research and analysis. TR is responsible for exploring the best compost conditions, developing compost facilities, and improving the production speed and quality of compost.

e Social organization: The main consideration for an NGO is the resource utilization of waste and the reduction of waste. It also concerns the promotion of household food waste classification and compost application, urging the government to adopt environmentally friendly measures.