A Field Study on Revival Conditions of Covered Rivers in Tokyo's 23 Wards

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Abstract

With the rapid urbanization of Tokyo, many rivers were covered with concrete, mainly to provide open spaces or roads and for the development of public sewerage lines, etc. Recently, there has been renewed interest in the importance of rivers in cities for the improvement of urban environment problems, e.g., heat islands, as well as to provide recreational spaces close to rivers for city dwellers. It is important to arrange green spaces along with access to rivers to improve the urban environment. This study was carried out to investigate the possibility of reviving the covered rivers in Tokyo's 23 wards. An evaluation index was made based on field research of the present condition of covered rivers: i.e., conditions of open spaces above covered rivers, water supply, and reservoir setting to rewater the rivers. Of the covered rivers examined, 0.7% qualified for revival with respect to all of these physical conditions. Research into the volume of sump water is expected to provide new methods for reviving covered rivers and the percentage of revival may increase.

Keywords: revival of rivers; covered rivers; recreational spaces close to rivers; urban environment of cities; heat island

1. Introduction

1.1 Purpose of this study

There is a great deal of renewed interest in the importance of rivers in cities for the improvement of heat islands as well as the provision of recreational spaces. In fact, a road covering Cheonggyecheon River was removed, reviving this river in Korea (Cheonggyecheon restoration works). This will contribute to improvements in Seoul in several respects. In Tokyo, many small and medium-sized rivers were covered with concrete or were turned to sewage or filled in due to the sudden population increase in Tokyo's 23 wards after World War II1). In addition, an overpass covers Nihonbashi River, spoiling the view and blocking access to the river. However, with the rapid expansion of the public sewerage system, revival of these covered rivers has become possible. Revival of these rivers will be an effective means for improving the city environment and creating recreational spaces close to the rivers. This study was performed to determine which of these rivers are the best candidates for revival, to ascertain the conditions necessary for revival by surveying actual covered rivers and administration attitudes, and to investigate the possibility of revival of covered rivers in Tokyo's 23 wards.

1.2 Definition of covered rivers

Covered Rivers are waterways that have structures produced using the cast-in-place concrete or box culvert construction method covering part or all of the width of the river. Fig.1 shows a section of a covered river. "Legal covered rivers" and "public covered ditches in 23 wards without legal covered rivers" are also included.

The dimensions of rivers are usually categorized by the contributory area, and wide rivers were excluded from this study. Major rivers, such as Arakawa River, Tama River, Sumida River, Shingashi River, and Nakagawa River, were not included in this study.

1.3 Outline of the study of covered rivers

First, we adopted a number of small to medium-size...
sized covered rivers in Tokyo's 23 wards as subjects for study.

A field survey of small and medium-sized covered rivers was performed, along with examination of a report from 1998 and past maps from 1925 and 1937\(^3\). We measured the length of the centerline of each river on past maps and determined the positions of open conduit rivers at various times in the past.

After determining the locations of covered rivers, a survey of their present conditions was carried out.

### 2. The present condition of covered rivers

#### 2.1 Space on covered rivers

A field survey of covered river spaces was performed. Widths of greenways, parks, and roads were measured by electronic means (measurement accuracy, 99.5%) in the field. The spaces were divided into roads and housing sites 67%, greenways and parks (not-reproducing waterways) 27%, and greenway and parks (reproducing waterways) 6%. The positions of the spaces on covered rivers were determined from maps, and rivers on which greenways and parks were present were determined by the field study. The distribution is shown in Fig.2.

#### 2.2 Underground parts of covered rivers

A survey of the sewer ledger was performed with regard to the underground parts of covered rivers. These were divided as follows: combined sewer system 79.4%, waterways (underdrain) 20.2%, and separate sewer system 0.4%. The distribution is shown in Fig.3.

#### 2.3 Survey of administration attitude

##### 2.3.1 Attitude regarding revival of rivers

A survey of the attitudes of the administrations of Tokyo's 23 wards regarding the revival of rivers was carried out. Replies were obtained from 20 of the 23 wards. The items investigated were as follows:

1. Conditions required for revival of covered rivers
2. Intention to revive covered rivers when these conditions are met
3. Existence of measures for revival of rivers

The results are shown in Figs.4., 5, and 6. As shown in Fig.4., the main condition required by the administrations for revival of covered rivers was resident approval.

Scores were determined from ranking of the conditions by the administrations of Tokyo's 23 wards. Points were given in the order of ranking: for example, first was given a score of 7 points, second was given a score of 6 points, third was given a score of 5 points, etc.

##### 2.3.2 Attitude regarding separate sewer system

A survey of the attitude of the Sewerage and Sewage Purification Department of Tokyo concerning changing the combined sewer system into a separate sewer
3. Suggestion for revival of covered rivers
3.1 Conditions necessary for revival

The conditions necessary for revival were considered based on the present conditions of covered rivers. Social conditions included approval of residents, reservation of budget, necessity of the space for recreation, and revision of the river law. Physical conditions included extra space on covered rivers, reservation of amount of water, and improvement of water quality. This report discusses the physical conditions because a lack of such conditions will make revival of covered rivers impossible.

3.2 Conditions of space on covered rivers

We assumed that greenways and parks on covered rivers could be changed into waterways if the space for the walking trail remained. Based on the width of the waterways of existing water parks and the width of walking trails of existing water parks (Tables 1. and 2.), we set the width required for waterways to 2.64 m and that for walking trails to 2.14 m. These numbers were mean values up to two decimal places. The necessary space required to revive waterways on covered rivers was set at 4.78 m (Fig.7.). Among the 223 km of covered rivers in the area, 25% meet these conditions (Fig.8.).

3.3 Conditions of water quality

In covered rivers, combined sewer systems pass dishwater, while separate system sewers pass rainwater, and waterways (underdrains) pass stream water. Separate system sewers and waterways can utilize existing stocks, but combined sewer systems require approval. Rainwater, sewage treatment water, and sump water can be utilized as the sources of streams. Fig.9. shows the distribution of water sources and regenerable space.

3.4 Amount of water

3.4.1 Calculation of the necessary amount of water

Calculations of the necessary amount of water per month using the Manning Formula are based on the width, water depth, and flow rate with reference examples in Tables 1. and 2. The values were as follows: width, 2.64 m; water depth, 0.27 m; flow rate, 0.30 m/s.

- Manning Formula
  - Flow rate \( V (m/s) = 1/n \cdot R^{2/3} \cdot I^{1/2} \)
  - Flow volume \( Q (m^3/s) = A \cdot V \)
  
  \[(n, \text{Coefficient of roughness}; R, \text{Hydraulic radius}; A, \text{Flow cross-section}; I, \text{Gradient of water surface})\]
3.4.2 Calculation of water catchment capacity

Calculations of rainwater catchment capacity are based on precipitation and divides are determined from contour maps. A run-off coefficient of 0.3 was estimated as the minimum. In addition, sewage disposal plants located higher above sea level than the upstream regions of covered rivers are computed for available sewage treatment water (advanced treatment water volume) catchment capacity. It should be noted that sump water is not included in the amount of water, because sump water in Tokyo is not observed sufficiently. The percentage of covered rivers that fulfilled both the spatial conditions and had a sufficient amount of water was 1.3% (Fig.10.). The spatial condition was that necessary space (width over 4.78 m) existed on covered rivers.

3.4.3 Investigation of the possibility of water storage facility setting

Covered rivers with sufficient space for water storage facilities were investigated among the 1.3% that fulfilled both the spatial and amount of water conditions. Water storage facilities could be set underground below schools and parks in areas located in the divide. We examined whether water required by calculation (3.4.2) could be reserved by calculation of the capacities of rainwater storage facilities.

In the area investigated, which included 223 km of waterways, 1.3% of covered rivers meet the needs by rainwater and sewage treatment water, of which 0.7% can reserve water in underground water storage facilities below schools and parks.

4. Possibility of revival of covered rivers

4.1 Evaluation index

Covered rivers are classified according to conditions of revival in Fig.11.

![Diagram of Covered Rivers Classification](image)

Fig.11. Classification of Covered Rivers

| Conditions for Revival | Group 1 | Group 2 | Group 3 | Group 4 | Group 5 | Group 6 |
|-----------------------|--------|--------|--------|--------|--------|--------|
| Space on covered rivers | Greenways and parks | ○ | ○ | ○ | ○ | ○ |
| Space required to revive waterway and walking trails | – | ○ | ○ | ○ | ○ | ○ |
| Amount of water | Reservation of amount of water | – | – | ○ | ○ | ○ | ○ |
| Water storage facility | Space of schools and parks the divede | – | – | – | ○ | ○ | ○ |
| Underaround part of covered rivers | Combined sewer systems | – | – | – | – | ○ | – |
| Separate system sewers | – | – | – | – | – | ○ |
| Rate of total length of covered rivers | 33.2% | 25.5% | 1.3% | 0.7% | 0.0% | 0.7% |

Table 3. Conditions for Revival of Covered Rivers
4.2 Evaluation of possibility of revival

The possibility of revival of covered rivers was evaluated based on the results shown in Fig.11. Of the covered rivers, 33.2% are covered by greenways and parks, and 25.5% meet the spatial conditions regarding availability of necessary space on the covered river, because these are over 4.78 m in width and lie adjacent to greenways and parks. Of the total number of covered rivers, 1.3% meet both the spatial criteria and provide the necessary amount of water. Of these rivers, 0.7% can be set as reservoirs at schools and parks. This 0.7% of the rivers consists of waterways (underdrains) that pass stream water; so existing stocks are available for use. None of the covered rivers that met the conditions of extra space, amount of water, and reservoir setting have combined sewer systems.

Table 3. shows the revival conditions of covered rivers. Group 1 were rivers that were covered with greenways and parks. Group 2 were covered rivers among Group 1 with space (width over 4.78 m) required to revive waterways and walking trails. Group 3 were covered rivers that had a reservation of sufficient amounts of water. Group 4 were covered rivers that could have water storage facilities in schools and parks in the divide. Group 5 were covered rivers that had combined sewer systems. Group 6 were covered rivers that had separate system sewers. Therefore, Group 6 had the highest possibility of revival. Consequently, 0.7% of covered rivers fulfilled all of the physical criteria required for revival.

Figs. 12, 13, 14, and 15 show the distributions of Groups 1, 2, 3, 4, and 6 covered rivers, respectively. Groups 4 and 6 are the same rivers.
5. Conclusions and future tasks

5.1 Conclusions

There are a number of physical conditions that are necessary for the revival of covered rivers, such as the availability of sufficient space as greenways or parks or of extra space for water storage facilities. A good supply of water is also required. Based on these conditions, 0.7% of the covered rivers examined in Tokyo’s 23 wards can be revived, and these are all waterways (underdrains). Physical impediments to revival of covered rivers include roads or housing built over the covered rivers and poor water supply. Reduced width of greenways and parks may be another physical constraint, and inability to obtain the consent of local residents may also be a social impediment to the revival of covered rivers.

5.2 Future tasks

Of the total number of covered rivers in the area examined, 25.5% meet the spatial conditions because they are over 4.78 m in width and lie adjacent to greenways and parks. In addition, 1.3% fulfill both these spatial criteria and provide the necessary amount of water. If conditions regarding the necessary amount of water are satisfied, the possibility of revival of covered rivers is increased. Therefore, obtaining sufficient water supply is important for the revival of covered rivers.

Groundwater levels are rising in Tokyo’s 23 wards. Therefore, sump water is expected to maintain the water supply. Research into the volume of sump water is expected to provide new methods for reviving covered rivers. In addition, excess industrial water supply is also available.

References

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3) Bureau of Sewerage of Tokyo Metropolitan Government "Sewerage Ledger"
4) The Geographical Survey Institute (1925,1937) 1:10,000 Topography Map

Notes

A part of the present study was reported in the following research.

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