

Evaluating Best Practices to Control Residual Chlorine, THM and Coliforms in a Water Distribution System

A Case Study on Kandy South Water Distribution System

Harsha K. Abeykoon¹, A.A. Gayan D. Amarasooriya², Sujithra K. Weragoda³

1. National Water Supply and Drainage Board, Regional Support Center (Western North), Kadawatha

2. Postgraduate Institute of Science, Peradeniya

3. National Water Supply and Drainage Board, Gr. Dambulla WSP, Dambulla

INTRODUCTION

Chlorination has been the most common disinfectant used for domestic drinking water for many years in Sri Lanka. Chlorination could dramatically reduce the incidence of waterborne diseases such as typhoid, cholera, and hepatitis, as well as gastro-intestinal illness. However, chlorine can also react with natural materials in the raw water to form disinfection by-products (DBPs) that are hazardous to human health. Some epidemiologic studies have shown an association between long-term exposure to disinfection by-products and increased risk of cancer and potential adverse reproductive effects. Trihalomethanes (THMs) and haloacetic acids (HAAs) are the most important groups of DBPs in chlorinated water. Others are haloacetonitriles (HANs), chloral hydrate (CH), haloketones (HKs) and chloropicrin (CP).

THMs include chloroform, bromodichloromethane (BDCM), dibromochloromethane (DBCM) and bromoform. Total THMs (TTHM) refer to the sum of these four substances. HAAs include nine substances, dichloroacetic and trichloroacetic acids were the most common ones among them, while the other compounds were found generally at lower levels. In the United States (US), the regulated haloacetic acids, known as HAA5, are: monochloroacetic acid (MCAA), dichloroacetic acid (DCAA), trichloroacetic acid (TCAA), monobromoacetic acid (MBAA), and dibromoacetic acid (DBAA). HANs include dichloroacetonitrile (DCAN), bromochloroacetonitrile (BCAN), dibromoacetonitrile (DBAN) and trichloroacetonitrile (TCAN). The sum of these HANs was defined as total HANs (THAN). HKs include 1,1-dichloropropane (1,1-DCP) and trichloropropane (1,1,1-TCP) and the total HKs (THK) were regarded as the sum of the above two haloketones.

Kandy district, one of the major city areas of Sri Lanka, is located in the central part of the island. River Mahavali is the only surface water source for drinking water supply in this area. National Water Supply and Drainage Board (NWSDB) and municipality, provides more than 90% of city's water supply by treating this river water. The groundwater is also used as a raw water supply for several other areas. There are many water treatment plants in Kandy district. Among them Kandy South Water Treatment Plant is the second largest treatment plant which produce 32,000m³ /day of water covering 15 schemes.

When compared to the world, Sri Lanka still does not have sufficient data of DBPs. No researches were conducted to measure DBPs such as chloroform or trichloromethane (TCM), bromodichloromethane (BDCM), dibromochloromethane (DBCM) and bromoform or Tetrabromomethane (TBM). In order to understand the consequences of the future application of DBPs and to monitor and control the DBPs of drinking water in Kandy, a survey of disinfection by-product occurrence in Kandy South Water Scheme with other water quality parameters was conducted for the first time. Particular attention was focused on the distribution of the levels of DBPs with an emphasis on their seasonal and spatial evolutions in a water distribution system.

HIGHLIGHTS

- Sampling program was prepared considering the population density of the area of each scheme and considering the seasonal variations.
- Correlation between the system pressure and DBPs was to be identified
- Correlation between the age of water and DBPs was to be identified
- Correlation between RCl and DBPs was to be identified

METHODOLOGY/PROCESS

Water samples used in this study were collected from the distribution system in Mahakanda, Sarasavigama, University of Peradeniya, Hindagala, Pilimathalawa, Danture, Menikdiwela, Kadugannawa, Handessa and Peradeniya areas. A total of 30 points were sampled from August, September and October. From treatment plant, service reservoirs and user end points were selected for the purposes of water quality parameters and DBP measurements. The selection of end user sampling points was based on population served and it was one sample/ 5,000 persons. The four THM species were Trichloromethane (TCM) , bromodichloromethane (BDCM), dibromochloromethane (DBCM) , Tribromomethane (TBM). Other DBPs analyzed were 1,1,1-Trichloroethane (TrCEa), Carbon tetrachloride (CTC), Trichloroethylene (TrCEe) ,Tetrachloroethylene (TeCEe) ,1.2-Dibromoethane (DBEa) ,1.2-Dibromo-3-chloro-propane (DBCPr)

Samples were collected to amber coloured plastic bottles. Prior to sample collection $\text{Na}_2\text{S}_2\text{O}_3$ was added to the bottles as chlorine neutralizing agent. Collected samples were stored at 25°C and analyzed within two weeks.

Measurements of free chlorine were conducted insitu using the DPD colour comparator method with Hach test kit with DPD I powdered tablet. Water pH was measured using a solid selective electrode (electrolytic gel). Kuivinen and Johnsson, 1998 headspace method was used to determine the THMs and TrCEa, CTC, TrCEe, TeCEe, DBEa, DBCPr . Analyses of these DBPs were performed by gas chromatography using a Thermo scientific trace 1300 GC equipped with an electron capture detector equipped with headspace auto sample and heating agitator.

In order to monitor the precision and reliability of analytical results, no less than 50% replicate samples were examined in DBP analysis. Field blanks, which are accompanied with samples to the sampling sites were used to determine any background contamination. Method blanks and spiked blanks (standards spiked into solvent) were analyzed and were subtracted from the analytical results to remove the contribution of contamination in laboratory.

For the pressure analysis and water age analysis one particular scheme was selected considering the data availability and other properties of pipe network such as distribution length, coverage area etc. For that Maligathenna WSS was selected and hydraulic modelling work is in progress to correlate the spatial variation of DBPs with system pressure and age of water in the system.

RESULTS

Among Trihalomethanes (THMs), TCM and BDCM were the major disinfection by-products found in treated water samples. DBCM and TBM were not detected in any of the samples.

TCM was the most abundant THM, with the concentration ranging from 0 to $34.09 \mu\text{g/L}$ and mean concentration was $11.5 \mu\text{g/L}$. Second abundant was BDCM and it ranged from 0 to $6.778 \mu\text{g/L}$ and its mean value was $3.742 \mu\text{g/L}$. TrCEa, CTC, TrCEe, TeCEe, DBEa and DBCPr were not detected. According to World Health Organization, maximum allowable THM limit is $80 \mu\text{g/L}$ and study shows that total THMs found in Kandy South Water Supply scheme ranged from 0 to $38.25 \mu\text{g/L}$, and having a mean value

13.36 µg/L, hence not risky to the consumers.

Further the relationships between DBPs and several other factors such as RCI, System Pressure, Water age, Population Density (Demand) etc are to be identified. Research is in progress at the moment and final conclusions are not yet identified.

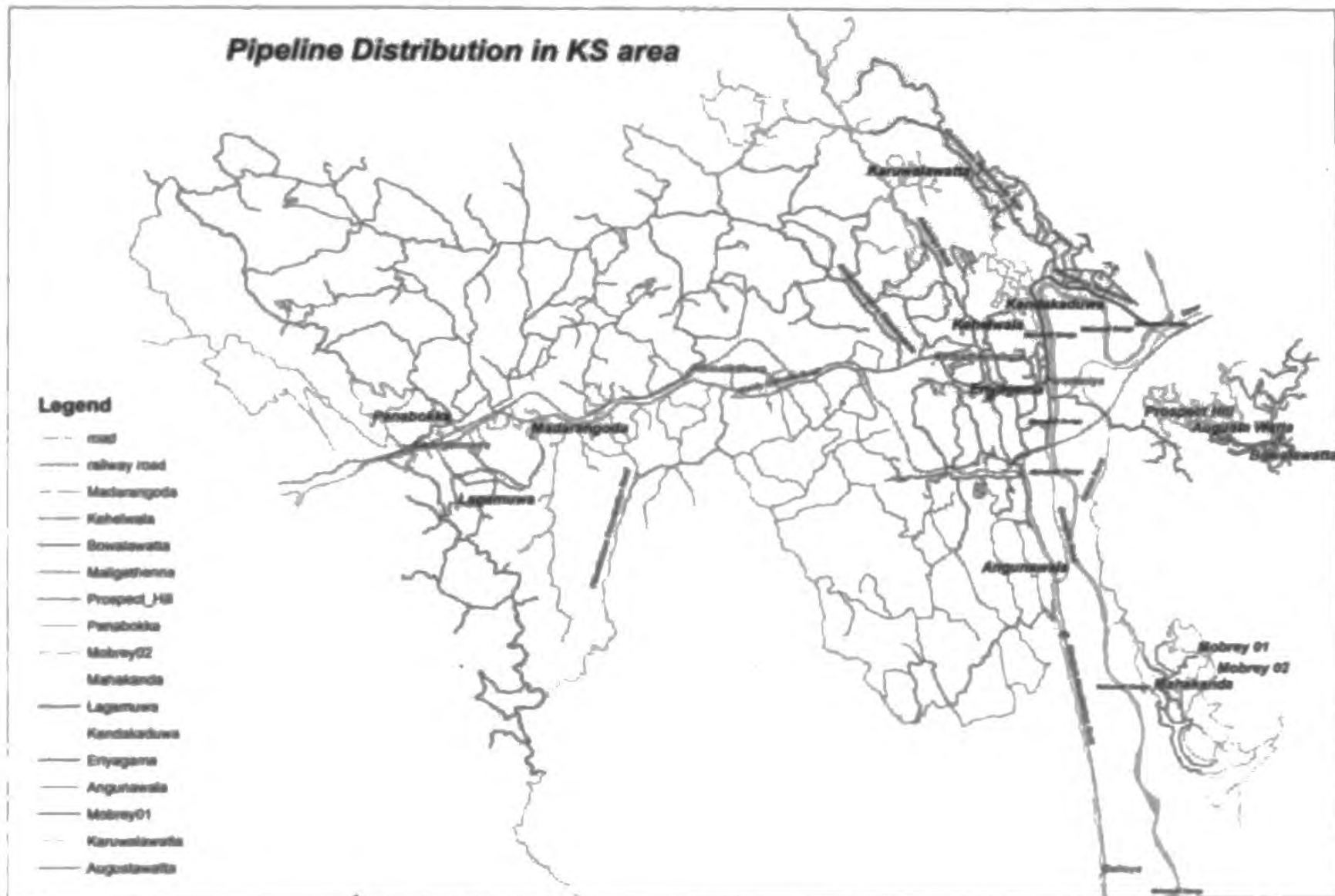


Figure 1: Distribution Pipeline Network of Kandy South Region

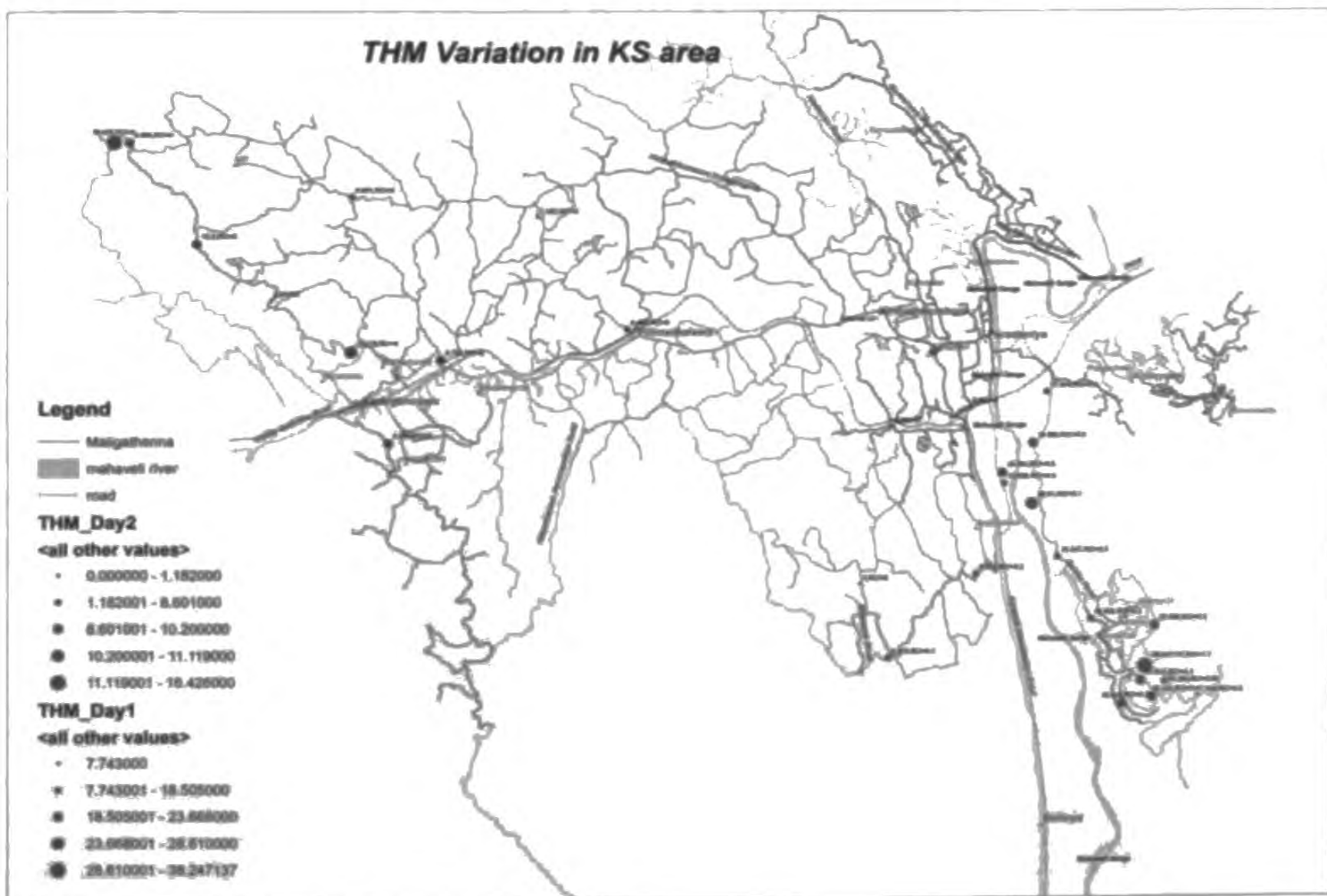


Figure 2: Spatial Variation of THM in the region

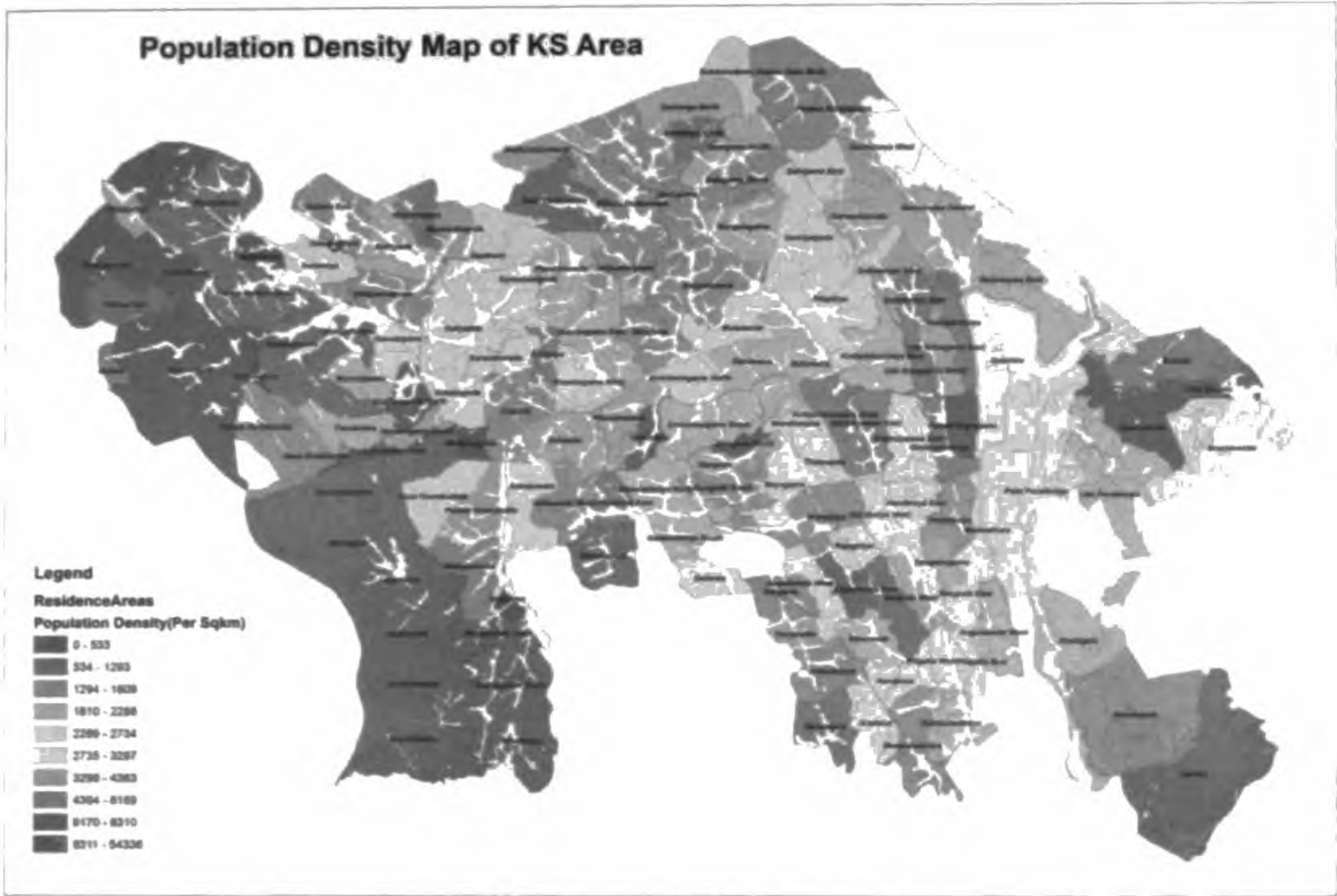


Figure3: Population Density map of the Region

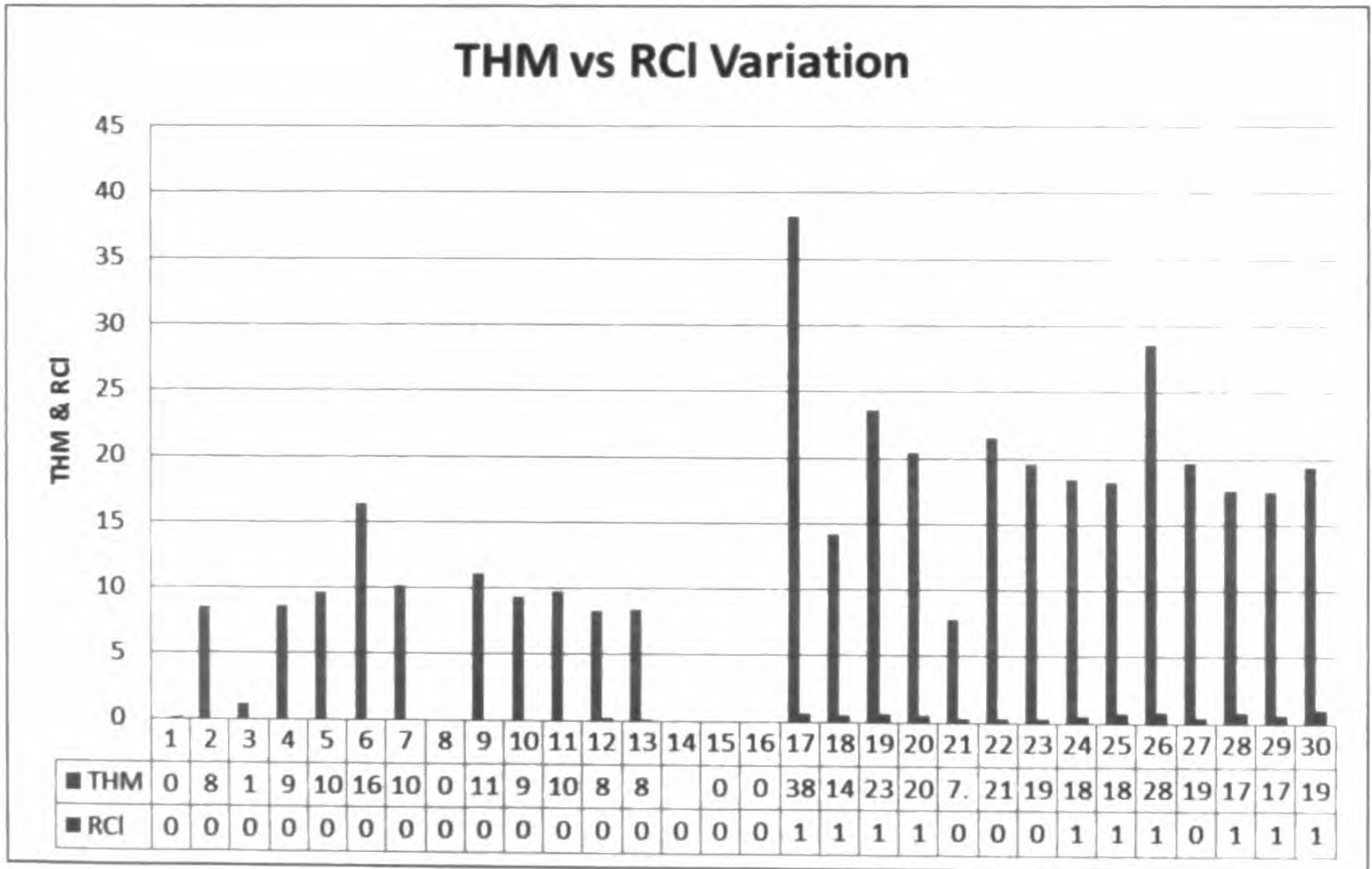


Figure4: Relationship between THM and RCI