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Modeling Sewer Overflow of a City with a Large Floating Population

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Abstract

The sewer system of many historical or holy cities is not well associated with the present need. The managing of the sewer system of such cities is very difficult. Karbala, located in central Iraq, is one such city that experiences tremendous pressure on its sewer system due to large visiting population during special religious gathering. As the sewer system of Karbala city is not designed for such high population like many other historic or holy cities, the sewer overflows, inundate the roads, and degrade the environmental due to the polluted sewer during religious gatherings. The problem often becomes critical due to heavy rainfall as the gathering usually happens during monsoon. The modeling of the sewer water quantity with a varying population and rainfall is important for simulating the sewer overflow as well as to manage the sewer system. The modeling of the sewer water quality is also important to understand the possible environmental hazard due to the sewer overflow. In this present study, an attempt has been taken to simulate the spatiotemporal distribution of the sewer water quantity and quality with a varying population and rainfall for the prediction of sewer overflow and possible pollution susceptibility. The Stormwater Management Model (SWMM) will be used in the proposed study. The simulation will be carried out in the city center of the Karbala city where the stormwater network is not fully developed. It is expected that this study will help in the operational management of the sewerage system and mitigate the sewer flooding and related environmental problems.

Keywords: Sewerage system; Urban drainage; Stormwater management model; Sewer overflow

Introduction

Sewage is a generic term used not just for wastewater from homes and industries, but also for stormwater runoff, snow melt falling from the urban surfaces through gulleys and catch pits. Besides that, it includes the exotic water that infiltrates through sewers of groundwater, running water, and so on [1]. The urban areas characterized are with the dynamic change, in terms of population structure and land use. The changes of the population, the living standards of the population, increased per capita water demand etc. in combination with the changes of land use that caused a tremendous change in both quantity and quality of the sewage discharge. The sewer infrastructure needs to upgrade from time to time to deal with these dynamics. The inadequacy of the sewage system, improper design and the deteriorating sewage over the years make the system incapable of handling changing dynamics. Furthermore, the climate change may intensify the rainfall and shorten the flood return period in future [2]. Sewer overflow is a global problem around the world. According to EPA, 75,000 SSOs occur each year in the United States, resulting in the launch of between 3 billion and 10 billion gallons of sewage water untreated. Such events cause or contribute to the impacts of the environment and human health. Moreover, the report notes that there are several techniques of structural and unstructured list, which is perfectly suitable for the control of SSO. Since 1999, that was focused on issues with a USEPA SSO comply with assistance activities, enforcement, according to the "compliance and enforcement strategy to address the combined sewer excesses and sanitary sewer overflows. In addition, the evaluation of the EPA options for improving conditions of access to NPDES permits to regulate the municipal sanitary sewer systems. Sewer problem is different in pilgrim cities. The floating population is very high in such cities. Usually, a huge number of people visit the pilgrim city during holy or festival periods and increase the total population of the city by many folds. These huge floating populations caused an enormous pressure on the sewer sys-tem of the city. Usually, the sewer system of pilgrim cities is very old and placed in a historical location, and therefore, is very difficult to modify. Furthermore, it is not possible to build a huge sewer system for the huge population that visit the city only for a particular event in a year. These made the solution of the sewer problem of the pilgrim city much more complex. The research in this regard is very essential as the problem is becoming more intrigue with the population growth, economic development and people's ability to move. 17 million of the population of Iraq occupy about two hundred fifty city, but only 6% of these people enjoy the benefits of processing the plants sewage water. The remainder of the population depends on the individual septic tanks and other means of disposal. The rural areas, where an estimated 30 percent of people exist, there is virtually no sanitation systems. Cities with cesspit encountered big problems with high water tables. Urban populations and transforming wastewater on the streets by banks rainfall or disposal of, untreated, deliver straight to rivers. The Karbala city is growing very fast due to the urbanization and settlement of the rural population from adjacent are-as. Industrials growth is also play a major role in water utilization. The sewage network systems can be efficiently achieved by performing Land Use Mapping and using distribution system [3]. Over the last few years in Spain, a substantial financial effort was made to cope with the infrastructure for drainage and wastewater treatment. This is due to a growing awareness of the need for a rational use limited natural resources like water and commitment with the menu of legislation [4]. The significance of this research is to prove that there's a huge discharge through sewer system during pilgrimage period that causes the sewer to overflow,

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which in turn creates significant problems in terms of environment, public health and psycho-logical. The research will find the technical solution of this problem by modeling the spatial and temporal pattern of the sewer overflow. The novelty of this research is that it will identify the technical solutions of the problem of the sewer system of a city, whose population increased many folds in certain months and it is not possible to re-design the existing sewer system. The model developed in the research will be able to predict unknown situation that the city never faced before. Therefore, it will be possible to understand the future changes in the sewer situation due to population growth and adopt necessary measures to mitigate the impacts.

Pilgrims, who attend religious gathering in the Karbala city has increased over the years. However, the sewer system has not been upgraded with time to handle the pressure on sewer system due to the increased population. Consequently, the sewer system of Karbala often fails to handle the amount of sewer, produced by a large population, causing the sewer overflow, flooding and environmental pollution. The drainage systems of Karbala was implemented in 1970 and it is capable to handle a population of 572,300. At present, the number of pilgrims has increased to 18 million. However, the existing sewer system has not been upgraded accordingly. It is required to study the vulnerability of sewer system in order to identify the measures to mitigate the problem of sewer over-flow.

In this study, the following objectives will be explored to simulate the discharge into the sewer system during pilgrimage period, to model the spatial and temporal susceptibility of the sewer overflow, to predict the future changes in sewer discharge due to changes in population and climate and to explore the technical measures that can be adopted to mitigate the sewer problem of the holy city. The expected findings are by using SWMM5 and we will get the results after calibrating with the real results as well as with the older studies. Firstly, to help determine the locations and times for rash and flooding that helps reduce operational problems in the projects, sewage treatment. Secondly, we can calculate the amount of TSS and BOD in all manholes sanitation. Finally, we could estimate the flood, rash, TSS and BOD in sewers networks in urban areas for long periods of time 5 years, 10 years, 50 years and 100 years.

Previous Studies

The number of studies has been carried out in different parts of the world to model and mitigate sewer overflow due to the population growth and other changes. The details descript of previous studies in this regard is given below.

Sewer water quantity

A program was developed to strengthen sanitation practices in the Cook Islands where population varies widely with season due to tourists [5]. He reported that the primary treatment using multi-chamber septic tanks can significantly mitigate sewer pollution risks and adding a filter to septic tanks can further reduce such risks. An Artificial Neural Network (ANN) model was developed for predicting the condition of sewer pipes based on the historic condition assessment data in the United States. They aided in identifying the distressed segments of the overall sewer pipeline network using a set of known input values and also directed toward assessing and prioritizing the maintenance measures needed to prevent accelerated future distress and eventual failure of sewer pipes. A Life Cycle Cost (LCC) model was developed for operating and maintaining a wastewater sewer system based on the population and average household occupancy [6]. The essential components of a wastewater system have been identified and divided into sectors with housing, commercial, educational and recreational facilities in Texas. They calibrated using published data on various wastewater systems and they projected different rehabilitation and maintenance scenarios and identified the most cost effective approach to rehabilitate and maintain a wastewater system. A high-performance liquid chromatography (HPLC) was used to assess the potential impact of anthropogenic activities on aquatic environments in Sri Lanka, where due to the lack of municipal sewer systems substantial quantities of domestic sewage and untreated wastewaters are discharged directly into the lake [7]. They revealed that the fish populations residing in this lake is under threat due to the pollution stress that is mainly associated to the recurrent exposure to PAHs and toxigenic microcystis blooms in the Lake.

An innovative sewer line installation method was designed whereby, in lieu of the classic anti-seep collars and aggregate stone bedding material, flow able fill encasement was utilized in conjunction with an anchoring system in settings where a high risk of stream piracy exists to cover a population growth rate roughly three times statewide in The Nashville Metropolitan Statistical Area because it has experienced a significant growth during the past decade [8]. They revealed that the alternative construction methods employed were successful in retaining the stream's base flow, with no sub-surface loss detected as compared to pre-project conditions. A dynamic way model was used to improve water management in Paris, which has always followed population growth and by leading water in the streets to the main drainage and to preserve the environment [9]. He noted that the sewer system of Paris is considered to be one of the most developed and innovative in the world. The hydrograph separation method was used to estimate the infiltration of parasitical water into two sewer systems in Rome (Italy) was quantified during a dry weather period [10]. They identified that infiltration into the recent sewer in Torraccia is 14% and can be considered negligible given the precision of the method, while the old sewer in Infernetto has an estimated infiltration of 50%. Geographical In-formation System (GIS) was used to compute the extent of the area affected by concentrating on chokes occurring per region or on a grid basis in sewer Sydney [11]. They explained in their studies that the Sydney Water was making quick and effective decisions for potential chokes according to the risk that they im-pose on the environment and population. A program management technique used city staff to make a typical model used for major improvements of the sanitary sewer system required to keep pace with development and to replace an aging and undersized sewer system in the Anaheim City located within Southern California [12]. They found the possibility of controlling the discharge of high derived from large numbers of tourists 18 million annually, where many ways were applied to rehabilitate and develop the sewage, as well as the establishment of new lines and other advanced technologies adoption of significant financial support. A numerical watershed model were used to evaluate the potential influence of various point and nonpoint sources including on-site wastewater systems on stream nitrate concentration in Turkey Creek Watershed, Colorado [13]. They showed that there would be a significant increase in stream nitrate concentration with an increasing population, and also they discovered the conversion of on-site wastewater systems to sewers increased stream nitrate concentration, but decreased nitrate concentration in the bottom soil layer indicating that the on-site wastewater systems are beneficial with respect to stream nitrate concentration, but may increase nitrate concentrations in groundwater. High Level Sewer shed hydraulic mode were used to understand the system performance and develop recommendations to alleviate the overflow, flow monitoring and sanitary sewer overflows elimination planning efforts in the City of Baltimore [14]. They

indicated that the Hydraulic gradient line should be lowered at the downstream end with sewer rehabilitation; otherwise the overflow problem downstream will remain. The Info Works Collection System (CS) and Western Washington Hydrology Model (WWHM) were used to evaluate the use of decentralized strategies for reducing combined sewer system [15]. They have been used to store high flow volumes during the peak of a storm and also widespread use of cisterns and rain gardens by residents could significantly reduce the required volume of other traditional combined sewer system infrastructure by as much as 25 percent. They developed alternatives for pilot studies to support the alternative development; an array of decentralized strategies was evaluated for combined sewer system reduction benefits, as well as potential water quality impacts to Lake Washington. A computationally demanding 1D/1D model capable was used to estimate pluvial flooding fast enough in order to enable successful operational responses for reliable flood forecasting requires [16]. They have got the comparison of different overland flow networks generated with different levels of the sewer network. A sensitivity analysis is carried out in one catchment area in Coimbra, Portugal, in order to evaluate overland flow network characteristics. The basic spreadsheet mode was developed to quantify daily infiltration caused by rainfall or groundwater based on population and average household occupancy [17]. They calibrated based on published wastewater system information from various cities of various populations from different regions in the United States. Homogeneous and non-homogeneous poison process models were used to identify which parts of the sewer system are in most need of proactive removal of sediments in Bogotá (Colombia). They illustrated the potential value of customer complaints databases and formal analysis frameworks for proactive sewerage maintenance scheduling in large cities. A parsimonious model of flow capable of simulating flow in natural/ engineered catchments was developed and at WWTP (Wastewater Treatment Plant) inlets in Lausanne, Switzerland [18]. They indicated that a relatively simple approach is suitable for predicting the responses of interacting engineered and natural hydro systems. The next generation sequencing statistical analysis was used to describe the population dynamics of microbial communities in a previously characterized environment, urban sewer infrastructure in Milwaukee [19]. The Edmonton Watershed Contaminant Reduction Index (EWCRI) was used to create as a corporate performance measure for the City of Edmonton Drain-age Services Branch [20]. They found that the measure demonstrates the performance of Edmonton's Stormwater and Wastewater Utility. The smart technology of installing Sewage Treatment Plants (STPs) was used to address the impact of urbanization and ribbon growth in its population centers increase on sewers Pakistan [21]. He has given suggestions to overcome problems viable recommendations, for ex-ample the Replacement of Existing Sewerage System. A field measurement of the principal variables that affect the urban microclimate was realized and located in the urban area in Arequipa named Carmen Alto and modeling the measured by a microclimatic simulation by using the software ENVI-MET [22]. It was concluded that the control and influence in a microclimate with different vegetation proportions, for improving and use of the urban place, enhancement of the quality of life, for the creation of conditions adapted for the human habitat man-aging to limit the health risks for the design of a suitable ventilation and decrease the influence of the atmospheric polluters. Two dissimilar automated baseflow separation algorithms were used and Monte Carlo techniques to evaluate base flow in an urban watershed in the central of United States in order to mitigate urban development impacts on sewer system [23]. They noted that the base flow separation algorithms do not intrinsically describe the source of base flow or runoff, therefore contend that detecting hydrologic alteration in urbanizing watersheds may require more comprehensive considerations of urban hydrologic processes and techniques including the use of stable isotope methodologies. A substance flow analysis (SFA) was used as a tool for xenobiotics to detect the main problems in a sewer system and also to study different scenarios when actions are planned in the city of Lausanne [24]. They found that the surface water and the accumulation rate sediment are the most sensitive and also showed that stormwater is considered as the major source of contamination [24]. A rapid and cost-effective means was proposed to locate points of significant stormwater entry into the sewer system, which would be advantageous for combined and sanitary sewer management in the Barthman-Parsons area of Columbus [25]. They used rainfall-dependent inflow and infiltration (RDII) model to identify for private residential properties, which could include sump pumps, foundation drains, downspouts, cleanouts, yard drains, and defective service laterals. They reported eliminations without testing the entire population, offering significant savings in assessment and testing costs, and leading to an overall faster turnaround in system improvement. Several government developed tools were used to promote a consistent policy for sustainable stormwater management to reduce combined sewer overflow and the flooding risks in France [26]. They showed that stormwater regulation rules are now included in most municipalities sewer system regulation documents and land use plans. A static hystem-extran model and overland flow hystem-extran 2d module to assess urban flooding for a study area in the city of Hamburg, Germany [27]. They have computed the depth, extent, and propagation of floods only in the prone areas specified. SEM-EDX observations and ICP-MS measurements to constrain the spatial and temporal variability of the lead sources at the scale of the contaminated in sediment cores and combined sewer over-flow (CSO) in Seine River basin (France) [28]. They found a pervasive contamination of which the origin (coal combustion and/or gasoline lead) is caused by the current suspended particulate matter contamination trend that follows the urbanization/industrialization spatial trend. The MOUSE/ MIKE URBAN model was used to contribute to the standing debate concerning the advantages of separate sewer systems com-pared to traditional combined sewer systems and to simulate of pollutant loads in Aalborg, Denmark [29]. They reported what happened at the expense of an increase in volumes of stormwater and pollutant loads diverted to local receiving waters when detention ponds are not built in the new separate sewer systems. The Principal component analysis (PCA) and cluster analysis (CA) were used to determine if combined sewer system overflow affect the quality of water in watercourses during wet weather [30]. They proved clearly that the heterogeneity of the quality of wastewater of the individual collectors in the municipal sewage system during wet weather period's significantly increased.

Sewer water quality

Nutrient dynamics were studied in Saguling Reservoir, which become highly polluted, particularly with domestic and industrial effluent (organic matter, nutrients, heavy metals) from the urban areas of Bandung (population 2 million) [31]. They reported the water quality of Saguling will improve until a substantial part of Bandung is sewered and adequate discharge controls are placed on the many industries in the region up-stream of the reservoir. Analytical analyses, Caffeine analyses and Statistical analysis were used to evaluate the co-occurrence of caffeine and the extent of its influence front to other traditional water quality parameters (micro-biological indicator data) in way to characterize it as an efficient pollution indicator of anthropogenic origin in urban aquatic environments in Brazil [32]. They reported that monitoring caffeine fundamental in urban-stressed

aquatic environments where frequent accidental ruptures of sewage lines, pump station overflows or elevated numbers of inefficient septic tank systems are common. The GMAV5 software was used to estimate the impact of urbanized catchment discharge on the estuaries of Sydney, Australia [33]. They suggested that the intertidal rock assemblages in Sydney Harbor and surrounding estuaries appear to be responding to the quality and quantity of discharge from urbanized catchments and, furthermore, that assemblages are more suitable than individual taxa to indicate the difference between Bushes and anthropogenically disturbed estuarine locations. The inductively coupled plasma atomic emission spectroscopy (ICP-AES) was used for the analysis and calibration of heavy metals in sewage resulting from the different uses in Shanghai, China [34]. He found that the results indicate that metals have been reduced efficiently, but organic pollutants developped in aggravating trend as human sewage increase. The variation of the organic pollutant concentration, which are lower than other similar rivers in China, US, and Canada. An analysis using multiple regression analyzed and showed that bacteria concentrations of Tama River basin in Tokyo, Japan are significantly affected by population density [35]. They also reported that combined sewer overflow (CSO) and stormwater effluents contribute 4 to 23% to the indicator bacteria concentrations of the Tama River. A simple spreadsheet model was used to evaluate potential water quality benefits of high-density development in the United States [36]. They concluded that higher densities, such as those associated with transit-oriented development, could outperform almost all traditional BMPs, in terms of reduced loadings per a constant population. A combined Hydrodynamic-ecological model is used to analyze the development of water quality as a function of the load of organic material and nutrients in Nile Delta, Northern Egypt. They concluded that the restoration will undoubtedly bring about major ecosystem improvements that will benefit both people and biodiversity. Nevertheless, such changes will require political will, considerable financial resources and careful environmental planning. Multimodal analysis was used to estimate associations of the West Nile virus infection in Culex quinquefasciatus, humans, and dead corvids with selected risk factors including the distance to combined sewer overflow streams and catch basins, land cover, median household income, and housing characteristics in Urban Atlanta, Georgia, USA [37]. They referred strongly that combined sewer overflow affected streams are significant sources of Culex quinquefasciatus mosquitoes that may facilitate the West Nile virus transmission to humans within urban environments. And also they found may have direct implications for the surveillance and control of WNV in other urban centers that continue to use CSO systems as a waste management practice. A wireless sensor network was used to evaluate BMPs and water quality in urban creeks in Minneapolis [38]. They found another point of interest is that the fecal coliform populations within the pond are between 10 and 100 times smaller per 100 ml than populations within the creek just downstream of the pond and they suggested that there is a large source of fecal pollution, stemming from a source other than the pond. Statistical techniques to better evaluate the performance of wastewater treatment plants WWTPs in South Africa where large data are generated [39]. They found that the wastewater treatment system was to be efficient in removing heavy metals and these were found in the sludge: iron(11,300) 4zinc (820)4copper (180)4lead (20)4cadmium, but not anions and also the major cause of poor performance is the high volume of the wastewater, exceeding the capacity of the plant 10 times various statistical techniques and ArcGIS V.9.1 software to determine the water quality of the Tigris River in Baghdad, Iraq [40]. They found in central Baghdad, the water treatment plants are satisfying the standard conditions but the water supply network is in a poor condition. The magneto-ferrite treatment was used to reduce excess sludge production of the ratio of the sewerage treatment to population is increasing in Japan [41]. They described an approach to use electromagnets instead of permanent magnets. Electromagnets can be controlled easily with an AC power supply and they got results of experiments that have shown a good possibility for reduction of excess sludge. A mass balance model based on multivariate analysis was used to develop concrete controls for improving the environment (i.e., an environmental improvement policy) in the Gyaku River basin, Japan [42]. They concluded that it was particularly useful because many visible aspects of Japanese environmental management are not those that are rationally based on paradigms of decision making, which would be associated with environmental improvement and resilience. Phylogenetic trees and UniFrac analysis were used to evaluate the population structure and temporal dynamics of the dominant community members within sewage influent from two wastewater treatment plants (WWTPs) in Milwaukee, WI [43]. They illustrated that small differences in V6 sequences can represent phyloge-netically and ecologically distinct taxa and they provided an insight into microbial community composition and dynamics within the defined environment of urban sewer infrastructure. The ViCAs settling test was used to im-prove the understanding of the pollutant dynamics and their interactions in Canada [43]. They developed full-scale field data sets where the results show a good agreement between observed and simulated data both for the total suspended solids and the total chemical oxygen demand. A designated as expected-regret model, α-reliable model and β-reliable model were used to find a solution that also minimizes the expected regret with respect to total costs, but disregarding the most unfavorable scenarios in terms of expected regret [44]. They were developed for the North Baixo Mondego area, in central Portugal, the results were obtained through the models to provide clear insights into the planning decisions to make and do not require excessive computational effort. The Taulat tank system was used before the combined sewer overflow point at the beaches of Barcelona, Spain to reduce the pollution opportunities in a drainage basin and also to assess strategies for optimized management of sewerage networks [45]. They showed that the introduction of a large storm tank against combined sewer overflow significantly reduces the negative impacts associated with the discharges during rainy weather. Though a huge number of studies have been conducted on sewer water quantity and quality across the world, studies on sewer problem of the cities are with very high floating population is still very rare. Studies in this line are still in infancy. Extensive research with field data is essential to characterize the sewer overflow and identify the mitigation measures for such areas.

Floating population

A structural equation modeling was used to analyze the relationship among three variables (Land Cover Change or LCC, Economy, and Population) in Shenzhen, China [46]. They found that the urban expansion was not always at the expense of urban vegetation cover and the floating population had a greater effect than the registered permanent population. A computational model to describe the rural-to-urban migratory process by a deterministic social utility in Hangzhou, China [47]. The focus was on the influence of which the individuals suffer in the reference group that they are included. Finally, experimental results show the effectiveness of the propose model. China's 30 years' rapid urbanization process was reported as not a usual one, but a particular process promoted in the dual social-economic structure like household registration policy and land system, China's floating population has reached 261 million [48]. Three strategies were

proposed about construction of the central region village in China with the aim to contribute to the much better sustainable development of rural villages and to improve the co-development of both the rural and urban areas. The first is how to arrange the surplus rural laborers, how to make rural land use more economically and how to balance the development of urban and rural areas.

Method

Engineering problems were on the last 40 years gradually directed to employ computerized solving techniques. We will use the three models below:

- Geographic information system (GIS), will be used to map existing sewer networks and analyzing water and wastewater flows. As GIS is allowed to handle vast amounts of data, it will be used in the present research to present simulation output and identify the mitigation measures.
- The EPA Stormwater Management Model (SWMM), a dynamic rainfall-runoff simulation model, will be used for the simulation of runoff quantity and quality. The runoff component of SWMM operates on a collection of sub-catchment areas that receive precipitation and generate runoff and pollutant loads. The routing portion of SWMM transports this runoff through a system of pipes, channels, storage/treatment devices, pumps, and regulators. SWMM tracks the quantity and quality of runoff generated within each sub-catchment, and the flow rate, flow depth, and quality of water in each pipe and channel during a simulation period comprised of multiple time steps. The SWMM Version 5, running on the Windows operating system will be used in this study as it provides an integrated environment for editing the study area of input data, running hydrologic, hydraulic and water quality simulations, and viewing the results in a variety of formats. These include color-coded drainage area and conveyance system maps, time series graphs and tables, profile plots, and statistical frequency analyses [49].
- Sanitary sewer overflow analysis and planning: A suite of computer software tools known as SSOAP will be used for the quantification of rainfall dependent inflow and infiltration (RDII) for capacity analysis. The RDII prediction methodology of the SSOAP toolbox will be used to design a focused sewer condition assessment program and maximize the success of field investigation efforts. It will also be used as an effective means to assess the post-rehabilitation performance of the sewer system using the pre- and post-sewer capacity analysis [49].

Study Area

A Karbala is one of Iraq's wealthiest cities, it has an area 5,034 km^2, is a city in Iraq, located about 100 km (62 mile), (Lat: 32º 36' 51" N, Lon: 044º 01' 29" E) southwest of Baghdad profiting both from religious visitors and agricultural produce, and especially dates. It is made up of two districts, "old Karbala," the religious centre, and "New Karbala," the residential district containing Islamic schools and government buildings, and has an estimated population of 1,066,600 people (2011). Karbala experiences a hot desert climate with extremely hot, dry summers and cool winters. Almost all of the yearly precipitation is received between November and April, though no month is truly wet. The Karbala city has seven types of soil, as shown in the Karbala map in Figure 1 water body, mixed Gypiferous desert land, saline lake bottom land, river layer soils, Do. Poorly drained phase, River basin soils silted and sand dune soils, as shown in Figure 2. The topographic of the city and surrounding area is shown in Figure 3. The topographic factors have a direct effect on flow size and runoff velocity. Figure 4-7 shows the land use map of the Karbala city centre that the number of visitors to the city of Karbala during the season visits. It has more than eighteen during the sixty days of each year, as shown in Figure 5.

Conclusion

Sewer overflow is a major challenge in urban drainage/sewer system management across the world. The problem is much more severe in cities where the floating population is very high, especially in the holy cities where millions of pilgrimage gather for a particular period of time. The sewer discharge during that period increases enormously, which the existing system cannot handle and therefore,

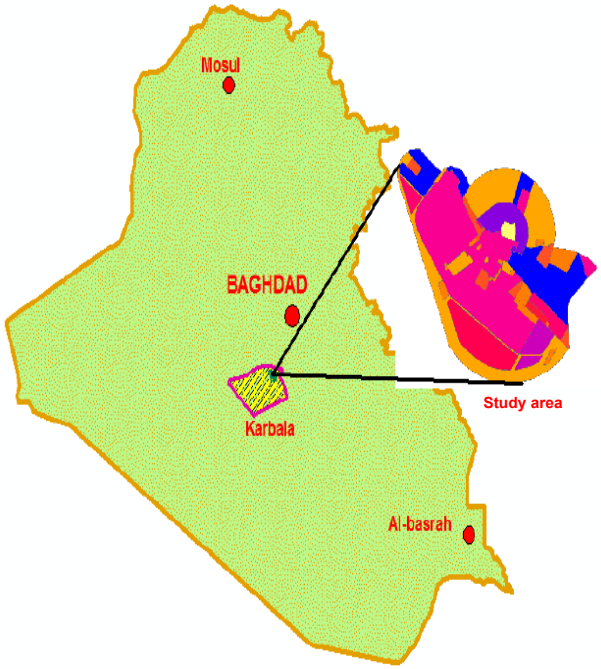

Figure 1: Map of Karbala.

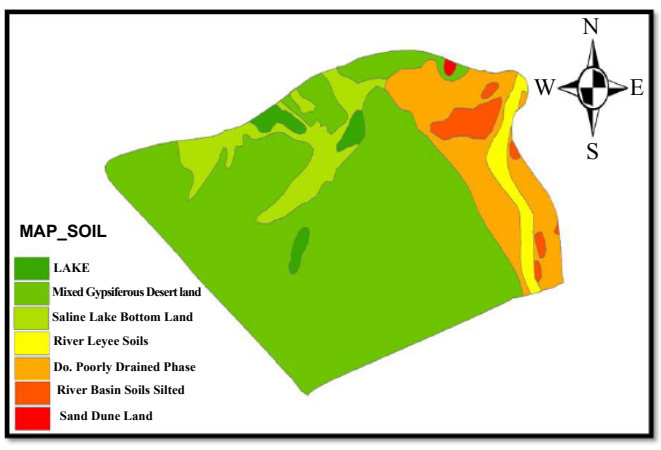

Figure 2: Soil of Karbala.

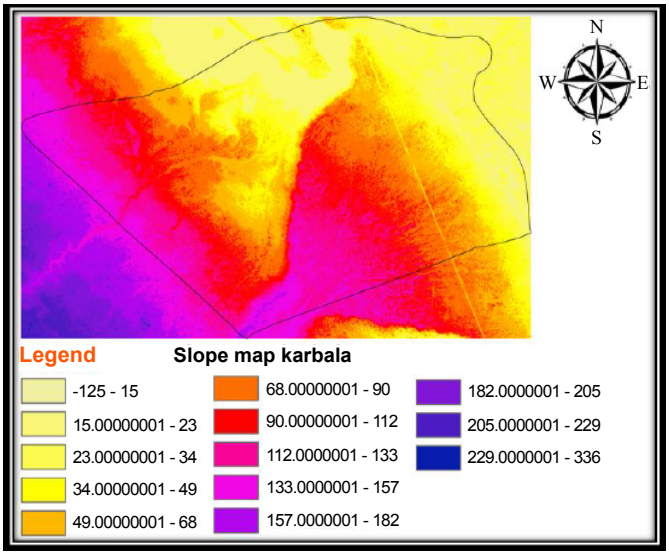

Figure 3: Topography of Karbala.

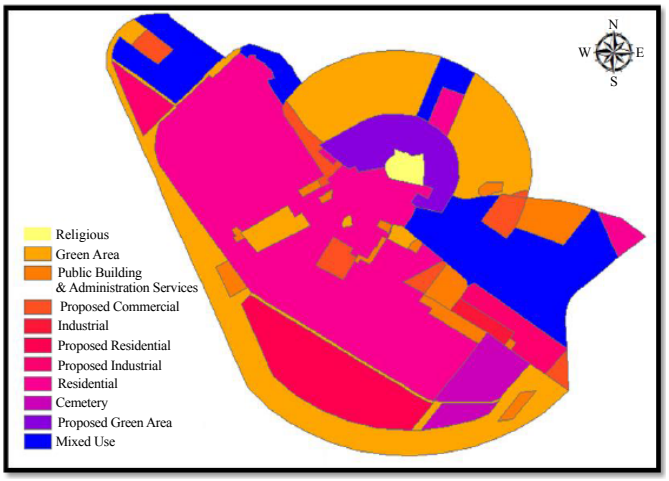

Figure 4: Landuse of Karbala.

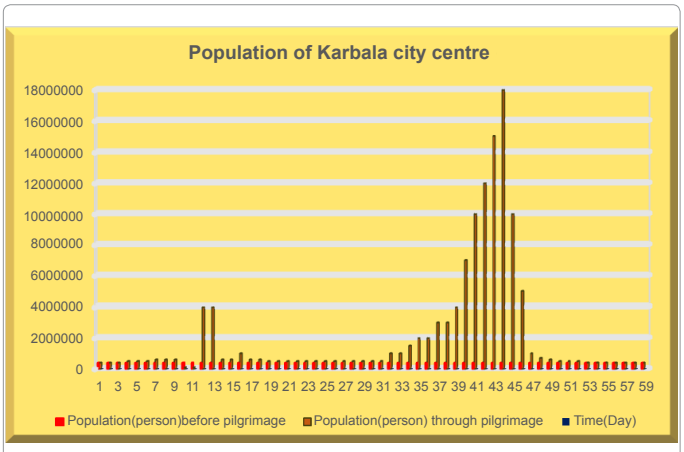

Figure 5: Relationship between population before and through pilgrimage days.

cause sewer overflow. If it is coincided with the rainfall, the situation is aggravated further and caused a widespread overflow and flooding all over the city. The present research is proposed to develop a model to solve this problem for the Karbala city of Iraq, which is one of the most crowded pilgrimage cities of the world. The research will develop a model for a precise prediction of spatial and temporal distribution of sewer overflow. The research will also identify the possible technical measures that can be taken to mitigate this problem in the context of the growing population. It is expected that the research will advance the knowledge on solution of sewer problem for the urban areas with a large floating population.

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