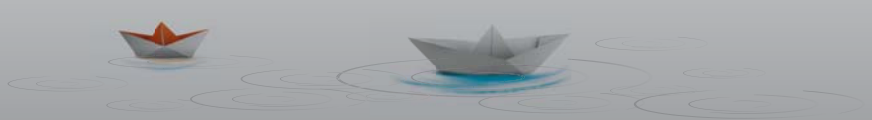
rainwater harvesting

2nd Bangladesh convention 2014

Book of abstracts



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Rainwater Harvesting: Potentials and Limitations in Bangladesh

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Rainwater is the main source of both surface and groundwater resources. Bangladesh receives 1500 to over 3000 mm of rainwater every year, which replenishes soil moisture, recharges groundwater and enriches surface water resources. Harvesting of a small part of the total available rainwater before joining surface and groundwater resources can provide water of very good quality to meet all domestic requirements including drinking. Rainwater harvesting has gained greater importance all over the world in the face of fresh water scarcity and indiscriminate pollution of surface and groundwater resources. Arsenic contamination of groundwater, salinity in the coastal area, lowering groundwater level in some areas and non-availability of reliable water sources in hilly areas have brought rainwater harvesting in the fore front as a source of drinking water in Bangladesh. Rainwater harvesting was adopted as an alternative source of water supply in arsenic mitigation and hundreds of units were constructed in the affected areas. Although rainwater harvested for drinking water was of superior quality as compared to other alternative options installed for arsenic mitigation, the use of the system was not encouraging for several reasons. However, in the coastal acute salinity problem areas rainwater harvesting system is well adopted. In the hilly areas, in the absence of easy access to a reliable source of water, rainwater harvesting is a potential technology for water supply. Rainwater harvesting, being mostly a single household option, is relatively more costly. Rainfall in both coastal and hilly areas is 50 percent higher than the average rainfall in Bangladesh, which makes rainwater harvesting more feasible in these difficult areas. The poorer section of people having no suitable roof is in disadvantageous position in respect of rainwater harvesting. Urban rainwater harvesting is still in pilot scale and needs extensive promotion. Incorporation of rainwater harvesting in the Bangladesh National Building Code initially for groundwater recharge and non-potable use is a big step forward in the this direction. This paper presents the potentials and limitations of rainwater harvesting in Bangladesh based on the experience gained by promoting rainwater harvesting in the last decade. Rainwater harvesting has been critically analyzed in the context of rainwater availability, rainwater quality and health risk, system design and operation, management, monitoring and surveillance requirements in Bangladesh. Increased rainfall, prolonged dry period and their variability predicted due to climate change will make rainwater harvesting more costly and unreliable as a source of uninterrupted water supply.

Keywords: Rainfall, coastal and hilly area, surface water, groundwater, Bangladesh

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Assessment of the Potentialities for Managed Aquifer Recharge Using Pond and Abandoned Well at the Dhaka University Campus

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Dhaka is the 10th largest megacity of the world where more than 85% of the current water supply comes from groundwater through more than 600 deep tube wells installed both in the upper and lower Dupi Tila aquifers beneath the city. Due to the rapid urbanization, the buildup area has been increasing every year resulting into significant decrease of natural recharge areas. Another consequence of this is increase in surface runoff during monsoon due to rainfall resulting into wide spread water logging in most part of the city. Due to combined impacts of decrease in recharge area and large scale abstraction for meeting the demand of the rising population, groundwater level is declining at an alarming rate of more than 3 m/year. A large part of the upper Dupi Tila aquifer has been dewatered and DWASA has to install new deeper wells abandoning the shallower ones. Dhaka University, the highest echelon of academic excellence is located in the southwestern part of Dhaka and has its own water supply system. Like other part of Dhaka, the University fully relies on groundwater and produce 11.4 million liters water per day through 10 deep tube wells. Groundwater level is more than 50 metres below the ground surface and the rate of water level decline is very similar to other parts of the city. The total annual rainfall recorded in Dhaka city is 2200 mm creating huge potentials for managed aquifer recharge by collecting rooftop rainwater or surface runoff accumulated in the ponds. There are 7 abandoned wells in the campus which creates another option for augmenting the declining groundwater resources. Department of Geology with support from UNICEF Bangladesh has undertaken a research project to assess the potentialities of managed aquifer recharge by combined use of rooftop rainwater and pond water through purpose built recharge shafts or existing abandoned wells. Three pilot sites for managed aquifer recharge have been identified based on the source water availability, existing land use and subsurface conditions. This study would provide evidences about the impacts of managed aquifer recharge on quality and quantity of water in the vicinity of the systems. The study would also demonstrate the use of pond and abandoned wells for administering recharge to the underlying depleting aquifer. If the research outcomes are positive, the same method can be up-scaled in other parts of the campus and Dhaka city.

Keywords: Aquifer, deep tubewell, DWASA, recharge, rooftop rainwater

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Social Acceptability of Rainwater Harvesting in Arsenic Affected Areas of Bangladesh: The Early Years

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The arsenic crisis of Bangladesh is well documented. In the year 2000 United Nations Children's Fund (UNICEF) undertook a four Thana arsenic mitigation action research project to supply safe water options to arsenic contaminated areas. One of the safe water options introduced was rainwater harvesting for the first time in rural Bangladesh that had a firsthand opportunity to discern and understand the advantages and limitations of rainwater harvesting application in arsenic affected areas. The project was a dynamic learning laboratory to understand the socio economic factors that makes a technology acceptance possible to the rural Bangladeshi population. This presentation and the accompanying paper will discuss all the technical, social, and economic challenges faced in promoting rainwater harvesting in arsenic affected rural Bangladesh.

Keywords: Rainwater harvest, arsenic, technical, socio economic acceptability

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A Review of Some Technical Aspects of Urban Rainwater Harvesting Systems

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Rainwater can replace potable water for several less quality-demanding water uses in an urban environment such as house toilet-flushing, terrace cleaning or private garden watering and can reduce the burden on the municipal water supply and waste treatment facilities to some extent. This has been realized in several developed countries who have adopted rainwater harvesting for similar purposes. With proper design and management, a rainwater harvesting system can provide a significant portion of domestic water needs for a community. Therefore, a sound knowledge of various technical aspects related to design and operation of urban RWHS is necessary for the engineers and planners. An attempt has been made in this paper to present some of the recent advances in the state of knowledge regarding the design and operation of urban RWHS. Aspects that were covered in brief are the methodologies to select a size of an RWHS storage tank, determining the reliability of an RWHS under various operating conditions and choosing the optimum size for the storage tank under cost constraints. Water quality issues related to RWHS as well as water quality management strategies have also been discussed. The aim of this paper is to bring forward the key elements that need to be studied in order to gain a comprehensive understanding of the design and operation of urban RWHS.

Keywords: Potable water, design, operation, urban RWHS

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Rainwater Harvesting in Building: Planning Perspective

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Rainwater harvesting needs different and diverse approach for different purposes of use of rainwater. Rainwater harvesting in building has some special aspects which differs from those features of rainwater harvesting in various other sectors. In buildings rainwater is mostly used as supplementary source of water for mitigating the demand which is falling short in main water, in terms of quantity and quality. If the quality of main water is not drinkable directly then it is to be decided which water is to be treated for making potable considering pollution potential in water from both the sources. Again rainfall, being the very natural phenomenon, its availability totally depends upon the spatial climatic condition. In building the features, characteristics, dimensions and positioning of the essential components of rainwater harvesting varies depending upon the type of occupancy, size, shape and location of the building. Among the components storage is the major issue and challenge as well. In storing rainwater, size of storage primarily governs by the demand, rainfall and affordability of storing in terms of availability of space and economy. The efficiency of rainwater harvesting in building primarily dependents upon the location of the storage; other major components also play vital role in this regard. Depending upon the location of the storage, supply system is to be chosen. Generally there are three options in locating the storage reservoirs and in multistory high rise buildings it is four. In all the locations there are some advantages and disadvantages as well for which planning is a must before finalizing the architectural planning of a building. Planning is also needed for finding way of storing different quality of water collected from main and catchments. Likewise, positioning of various other components of rainwater harvesting in the building also need planning. Not only in locating or positioning the components of rainwater harvesting system planning is needed but while designing the system judicious planning plays vital role in ensuring the sustainability of the system. In this monograph various aspects of planning, involved in positioning and designing all the components of rainwater harvesting in a building, and has been delineated to emphasize its importance.

Keywords: Rainwater, demand, architectural planning, design

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Feasibility Analysis of Rainwater Harvesting for Large Reservoirs in Hilly Areas of Bangladesh: A Case Study in Nayapara Refugee Camp, Teknaf

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Due to complex geological profile, large depth of aquifer from the top of hilly surface and complex nature of hydro-geology, water supply system in hilly areas is largely dependent on surface water. During rainy season (June to September), surface water sources i.e. ponds, rivers etc provide water that people use, with or without any treatment. But during dry period, these sources become limited and scarce. The stored water in ponds is mainly rainwater which reaches these ponds through surface runoff. Therefore, availability of rainwater, rainfall pattern and storage capacity of reservoirs are critical in terms of water supply in dry period in these areas. To address some of these issues, a study was undertaken on a rainwater based water supply system in Nayapara Refugee Camp in Teknaf upazila under Coxs-bazar district, where refugees of the camp are solely dependent on a reservoir which is fed by rainwater. During the study, analysis of surrounding catchments, soil properties of catchments, runoff pattern and quality of water were analyzed. The study thoroughly revealed the existing water crisis scenario of Nayapara refugee camp, based on which recommendations were made to increase the capacity of the reservoir to supply targeted amount of water to the refugees throughout the year.

Keywords: Aquifer, dry period, Teknaf, reservoir

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International MAR/Water Buffering Experiences

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Managed aquifer recharge and water buffering are both terms to describe the efforts to increase resilience of water systems by making better use of storage. Water buffering in fact is the broader term while MAR is one of the technologies to create water buffers. The presentation will provide an overview of the water buffering concept and principles and explain the specific but important of role of MAR in water buffer management. Water buffering has long been seen as a typical intervention for dry (arid) regions where long dry spells makes the need for storage an obvious requirement. Indeed the ancient Qanates in the Middle East are well known and during the last decades, the Horn of Africa has experienced a rapid growth in the construction of sand dams and subsurface surface dams. Application of MAR in humid areas, including in Europe is a more recent phenomena and related to the water quality. Especially in the saline environment in delta countries like Bangladesh and the Netherlands there a seasonal shortages of fresh water for drinking or for agricultural use. The MAR project in Khulna is good example of water buffering for drinking water supply in Bangladesh while in the Netherlands a number of pilot projects are ongoing for on-farm fresh water storage as source water for summer irrigation of cash crops. This presentation will introduce the broader concept of water buffering, give an update of new mapping tools to plan water buffering in dry areas and summarize the experiences in the Netherlands with on-farm water buffering and its linkages with the MAR project in the Khulna region.

Keywords: Recharge, buffer, fresh water, Bangladesh, Netherlands

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Urban Rainwater Harvesting: WaterAid Experiences

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Despite the fact that the Dhaka city receives annual average rainfall of about 2000 mm, a severe water crisis has been observed in many parts of the city over the last couple of years. Yet this large amount of rainfall is unutilized and drained out through storm sewer. Moreover, over extraction of groundwater is resulting declination of water table at a rate of 3 m per year which is aggravating the situation further. Therefore, Rainwater harvesting could be considered as a potential solution for meeting the emerging water crisis in urban context. To promote urban rainwater harvesting, WaterAid facilitated technology transfer through demonstration plants of RWHSs constructed at different strategic locations that include Bangladesh University of Engineering and Technology, Independent University Bangladesh, Military Institute of Science and Technology, Shahjalal University of Science & Technology, University of Information Technology & Sciences and a national NGO; Village Education Resource Centre. Moreover, to mainstream RWH in technical education, the WaterAid took initiatives to include related contents in the syllabus of different technical institutions of both universities and polytechnic institutes. Furthermore, policy dialogues were promoted at several forums to sensitize the policy makers and influence them. Again, WaterAid supported capacity building of the practitioners and researchers through arranging training on RWHS and strengthening national agencies like ITN-BUET and Rain Forum on particularly RWH. In order to create mass awareness, WateAid also supported different voluntary platforms to organize and observe Rainday (Bengali month 01 Ashar) across the country. This paper consolidates the WaterAid's experiences on multiple initiatives of RWH to put the system into practice.

Keywords: WaterAid, technology transfer, syllabus, policy dialogue, awareness

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Developing Ideal Practice of Rainwater Harvesting in Urban Areas

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With rapidly depleting groundwater table due to over-extraction and increasing pollution of surface water in urban areas like Dhaka city, rainwater harvesting is thought as a potential alternative source of fresh water. ITN-BUET initiated a research in 2012 in collaboration with WaterAid Bangladesh aimed at promoting rainwater harvesting through ideal practices in operation, maintenance and monitoring of storage water, and utilizing rainwater for groundwater recharge. As a part of this research, four rainwater harvesting systems installed at BUET, Village Education Resource Center, Independent University Bangladesh, and University of Information and Technology Sciences are being monitored. All systems have two components; a storage system where water is stored for direct use, and a recharge system to replenish groundwater table. To ensure acceptable water quality, different types of filter materials are being used in the filtration chambers of storage systems, and UV disinfection is being used in the storage chambers. Effects of cleaning of catchment, filtration chamber and storage tank on quality of harvested rainwater are being monitored. Monitoring well has been installed to monitor impact of rainwater recharge on groundwater. Flow meters have also been installed at selected points of the system to record total amount of stored, used and recharged water. Microbiological quality of harvested rainwater along with some physical parameters (pH, turbidity, color, TDS and TSS) are being tested at selected sampling locations. Based on the results of the study, ideal practices of urban rainwater harvesting will be developed.

Keywords: Groundwater recharge, water quality, water quality tests, urban rainwater

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Household Rainwater Harvesting for Drinking Water Source in Coastal Area of Bangladesh

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The coastal region of Bangladesh has been identified as the most climates induced hazard-prone hard-to-reach area in Bangladesh. Drinking water sources (rivers, ponds and groundwater) in coastal region has become contaminated recently by saline water due to saltwater intrusion from rising sea levels, frequent natural disaster, shrimp farming and upstream withdrawal of freshwater. Rainwater harvesting is one of the measures for reducing impact of climate change on water supplies. The objective of this study is about to establish whether harvesting rainwater is suitable or not for drinking purpose in coastal area of Bangladesh. The Khulna and Bagerhat districts (the districts are the first tier of administrative units of local government in Bangladesh) were selected for this study. The annual rainfalls of over 1900 mm with inter annual variability of 0.18 makes rainwater harvesting ideal in the coastal area. Rainwater harvesting is found technically feasible on the basis of rainfall, roof size and roofing material. Harvested rainwater can satisfy household monthly drinking water demand from March to October. The excess rainwater stored in September and October is sufficient to meet the demand in the dry months (November to February) provided there is adequate storage facility. The adaptation feature or implications of climate change with harvested rainwater is estimated as an appropriate alternative strategy for drinking water supply in coastal area of Bangladesh.

Keywords: Rainwater harvesting, coastal Bangladesh, drinking purpose

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Decentralization of Rainwater Management to Increase Urban Resilience in Dhaka City

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Now a days, Dhaka city becomes well known to world as an inhabitable and one of most densely populated city where 45,000 people lives in per sq. km. Dhaka City has undergone drastic changes in its spatial form, not only by territorial expansion, but also through internal physical transformations over the last decades. With these changes, Dhaka City has been gradually losing its urban resilience. Plots and open spaces have been transformed into building areas, open squares into car parks, low land and water bodies into reclaimed built-up lands etc which effects on tremendous pressure on urban land, utility services, and other amenities of urban life. A substantial growth of built-up areas is transforming increasingly the landscape from natural cover types to impervious surface and building up urban heat island, which has adverse effect on the urban climate change such as mostly on abrupt temperature rise, erratic rainfall and degrading air quality. Consequently, Dhaka city is affected by erratic rainfall and heat stress, resulting catastrophe like flood, water logging, drainage congestion, health outbreak, and water scarcity. Dhaka City is facing extensive water logging during the monsoon (May to October) as a common and regular problem of the city like water pollution, traffic congestion pollution. Though Dhaka City is surrounded by Balu River (east), the Tongi khal (north), the Turag-Buriganga Rivers (west) and includes 40 khals to drain the surface runoff to the surrounding rivers. As water log occurs during monsoon period and existing drainage system fails to smooth runoff of storm/rainwater, therefore it is obvious that there should be comprehensive plan to manage the storm water in decentralize way following indigenous practice and methods of rainwater harvesting from the urban roof top and green roof for extending its detention period of surface runoff. This study (based on secondary study) aims to seek the potentialities and challenges for storm/rain water management using those options (Rainwater Harvesting and Green Roof) in Dhaka City which contributes to minimize runoff into existing drainage system and utilizing rainwater in roof top vegetation for further buildup urban resilience.

Keywords: Climate change, urban resilience, green roof, water congestion, detention period

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The Functional Period for Rain Water Harvesting System in Different Zone in Bangladesh over the Year

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Drinking water comes from surface water and ground water generally. But ground water is highly contaminated with different health hazard components: Arsenic, Iron, salinity etc and the surface water are severely affected with different pathogenic bacteria, although the ground water source is less expensive compared to surface water sources, the treatment for all kind of water source is so much expensive. On the other hand day by day the depth of water table rising. The Surface water is polluted from agricultural, industrial, domestic and municipal sources. So, surface water needs an effective treatment earlier to supply in the distribution system. The rainwater is an alternative source of good potential for water supplies in Bangladesh. Bangladesh is a tropical country and receives heavy rainfall due to north-eastern winds during the rainy season. Rainfall is increased in the monsoon season and decreased in the winter season. Rainfall also varies zone to zone of Bangladesh. In this study, variation of rainfall will be shown in different season and also different zone of Bangladesh. Daily precipitation data all over the Bangladesh will be collected from the Bangladesh Meteorological Department (BMD).Then the goodness of fit of the data will be checked by using quantitative statistical test e.g Chi-square test, Kolmogorov-Smirnov test. Analytical frequency analysis, e.g. Gumbel distribution, Log-Pearson Type III (LP3) distribution will be used to estimate rainfall data for different return periods. As a result the period of precipitation over the year for different areas of Bangladesh will be estimated from the rainfall data of last 40 years. This area will measured surrounding of adjacent rain gauges. A specific catchment area, storage tank, and a specific family will be considered for this study. A rainwater harvesting system, number of months will be activated in a specific area over the country.

Keywords: Precipitation, arsenic, iron, water table, rain gauge

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Potential of Rainwater Harvesting in a Residential Hall to Reduce Groundwater Extraction – A Sustainable Solution for Near Future

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Demand for water in Gazipur city is rising geometrically because of increasing population, industrial revolution, rapid urbanization and the impacts of climate change. Extracting ground water by using submersible pump is more common practice in Gazipur district. Over extraction of groundwater to keep pace with the increasing demand of water and pollution of surface water has forced the water supply authorities in many places to think about alternate water sources for future. It is much known to all that the ground water table in Gazipur district is lowering considerably day by day making some previously installed pump inert. To resolve this upcoming shortage of ground water, Rain Water Harvesting as alternate water resources can be adopted effectively in Gazipur district. In this paper, an attempt is made to calculate the potential of RWH from residential hall at DUET campus. Also the possible financial benefit from RWH has been analyzed in this paper which would make people interested to practice rain water harvesting in Gazipur district.

Keywords: Groundwater, DUET, alternate source, pump

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Indigenous Knowledge and Local Perception for Rainwater Harvesting in the Drought Prone Northwestern Part, Rangpur, Bangladesh

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Water is a prerequisite for development of any form of life. This paper attempts to harvesting rainwater in draught prone area to mitigate water scarcity on the basis of indigenous knowledge. Although of the advancements of technology in recent pasts, the global scenario of water was still remain gloomy as all the inhabitants of the world do not have easy access to water availability. The paper focuses an option for uses of indigenous knowledge on rainwater harvesting in drought prone area of Rangpur, Bangladesh. Both quantitative and qualitative techniques were adopted to carry out in this study. The results revealed that water demand meet in drought prone area by using indigenous knowledge as a rainwater harvesting. More than 80 % people perceived that rainwater conservation using local knowledge for surviving in drought month. The results also had shown that more than 75 % people use local knowledge an alternative option to cope with the water crisis in the study area. Indigenous knowledge of collecting rainwater was served as a cheapest form of raw waters in the study area people. The number of victim people caused by water scarcity in northern region can cope with a greater amount of draught risk by harvesting rainwater.

Keywords: Draught, Rangpur, indigenous knowledge, rainwater

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Scope Assessment and Performance Evaluation of Rainwater Harvesting System in Academic Institution Covering Large Area: A Case Study on Independent University, Bangladesh

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Bangladesh is privileged by huge quantity of rainwater almost throughout the country, among all alternative water sources rainwater harvesting can be the most potential one for Bangladesh. Independent University, Bangladesh is one of the renowned academic institutions of Bangladesh where the water demand is so high because of higher number of students. The authority of the university was looking for a sustainable source of water which can also be an effective alternative to groundwater. As a result, the authority with the collaboration of WaterAid has installed the rainwater harvesting system to improve the practice of alternative source of water supply and to disseminate the knowledge among students, researchers, faculty members to wider audiences. The collected rainwater is used for both storage and recharge purpose via small scale de-siltation and filtration chambers. Stored water collected from the harvested system is used for toilet flushing and washing of the administration building. Currently the half of the rooftop area of academic building and a part of the rooftop of gymnasium building which is around 30% of the total available rooftop are used as the catchment area of the system which have the potentiality to harvest around 2,343,000 L of rainwater annually. About BDT 35,000 per annum can be saved using this harvested rainwater including the WASA electricity bill, the electricity consumption for groundwater extracting and maintenance cost for runoff of rainfall. In this paper a quantitative study has been done to investigate the potentiality of rainwater harvesting considering all the available rooftops of the university campus. If all the rooftops can be used as catchments, then certainly high amount of water can be produced for storage as well as for recharge purpose. This research outcome can assist to find out the amount of rainwater that can be harvested theoretically as well as the capability of this safe harvested rainwater to fulfill the total water demand. The outcome suggests that if underground tanks or other provisions can be made before the construction of the new dwellings covering large area, there is a scope of harvesting enormous amount of water. Some recommendations have also been made for further developments according the outcome of this analysis.

Keywords: Rainwater, water demand, catchment, cost, runoff

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A Study on the Alternate Source of Water and an Implication of the Rainwater Harvesting System in Dhaka City Slums

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Water, the elixir of life, is needed by mankind and creatures alike. Its uses and applications have made life easier for us. Water is a very important basic need of humans. Fresh water is a very valuable resource and getting more valuable daily. Increasing populations and technological growth have put the ecosystem we depend on under stress and the availability of fresh water is at a very high risk (UN, 2002). Consequently people need to utilize every source of water (surface water, groundwater, oasis water, rain water, etc.) to meet their demand. Reservoirs water supply is a new technology in which water is pumped from a large reservoirs and passed through a number of chambers containing sand and gravel and supply with properly designed pipe network. The treated water is usually safe for drinking. In Dhaka, we have an annual rainfall of about 1,854 millimetres, but due to land constraints, there are insufficient rainwater catchment areas. As Dhaka depends heavily on water and the demand is continuously increasing day by day rainwater or sometimes known as roof water can be a great option to meet this rapid increasing demand. The rooftops have a huge potential for rainwater collection. On the other hand the water level in our country is going downward due to the excess amount of water extraction from the ground. As a result it can decrease the possibility of future water scarcity.) The rooftops along with the free area of house have a huge potential for rainwater collection. Our aim is to come up with a suitable rainwater system to utilize this resource for non-potable uses and groundwater recharge.The objective of this study is to give a brief idea about the post implementation situation of the rain water facility given in Mohakhali slums area in Dhaka. On the basis of primary data, the study was done and random sampling was followed in this survey. It has been seen that regular operation & maintenance and the willingness of the users to use the rain water is the man driving force to keep operating the RWHS. Regular follow up can change the behavior of the target group. Mass campaign or raising awareness to change the behavior of the people in order to make rain water popular is requirement nowadays.

Keywords: Water quality, rainwater, Dhaka, slum

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Water Efficiency in Tall Building in Dhaka: A Case Example

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Water supply in Dhaka mostly depends on ground water. Because of continuing depletion of water table Dhaka Water Supply and Sewerage Authority (DWASA) is trying to get alternative sources to meet growing demands and surface water purification plants are already in operation to reduce the pressure on ground water. However, extensive levels of pollution of river water which can be the major source of surface water, becomes too difficult to purify because of the presence of heavy metal. A cumulative effort to use water efficiently and to reduce the wastage of water can play a significant role to address this issue. This paper will present a case example of a commercial high rise building in Gulshan area which has achieved 50% water efficiency compared to a same size commercial building at present. The sample case is an under construction sixteen storied green commercial building. The building is registered under US Green Building Council (USGBC) and preparing itself for Leadership in Energy and Environment Design (LEED) platinum certification. The building will use several strategies to reduce the water use without compromising the needs of the occupants. These strategies are rainwater harvesting, on site gray water recycling, use of water efficient toilet fixtures and use of native species of plants for landscaping. This paper will analyze these steerages and its practical implementation to understand how to achieve water efficiency in commercial tall building in Dhaka's context.

Keywords: Rainwater harvesting, commercial building, LEED, green, purification plants

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