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Physicochemical parametric and water quality index (WQI) analysis of Gomti River, Lucknow using MDSSS

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This research work was carried out to analysis of different physicochemical parameters and water quality index of Gomti River to examine the quality of water before directly using for different activities like municipal consumption, recreation, and other purposes. The Gomti River water polluted with various sources like industrial waste, agriculture waste, and domestic waste who discarded waste directly into the river water and water quality deteriorating continuously. Hence, the influence of the ecosystem as well as domestic activities due to water quality. Therefore, a modified double slope solar still (MDSSS) has been designed for the removal of this problem because it is cost-effective technology as compared to other conventional methods. After experimental work, analyzed various physicochemical parameters as well as WQI and found under the acceptable limit. Before solar distillation, these parameters showed that the quality of water not now in the safe limit, therefore needs to improve the quality of water but after solar distillation, all the parameters within the acceptable limit except turbidity, which was high even as NO_3^-, Cl^- and F^- are below the acceptable limit. The high level of pollutants disturbing the ecological system of rivers and affecting human health directly and indirectly.

Keywords: Physicochemical, desalination, yield, WQI, Gomti River, solar energy.

Introduction

Water is the most essential requirements of all living waterbody. The increasing the demand of fresh water and declining availability of conventional water supply sources are plays vital role on the development of other alternative water supply sources. The main sources of water for human activities are surface water bodies but it is affected environmental pollution as well as developmental activities. The basic needs of every living thing like fresh water, cloths, food, shelter and energy. The availability of water as per nation data as 97% in the ocean, 2% stored in ice in form, and 1% is clean water obtainable in earth for the requirement of the animals, plants, and human beings[1]. The fresh water is most important natural resources for the life because it is directly linked to human welfare. We all are know, the amount of water present in human body is about 57% and so its affect the cell activities and create various disease like headache, fatigue, nervousness, weakness, irritability and even death also[2,3]. It means the quality of water can be influences by the biological, physical as well as chemical contaminants.

The River Gomti is a flood plain river, which originates from Fulhaar jheel, in Madho Tanda (which is nearby Mainkot around 30 km east of Pilibhit district in Uttar Pradesh). It flows between latitudes 25°-26.9′N and 28°-9.1′N, longitudes 80°E-83°-9.6′N. The total length of the Gomti River is about 940 km. The Gomti River is the main source of freshwater to supply for necessities in domestic, industry, and agriculture purpose. However, the supply of water from these sources is not always doable or enviable due to the presence of more salts contents and detrimental microorganisms. Water pollution manly increased by rapid urbanization, industrialization, fertilization in agriculture and man-made activities, etc.[4,5].

The water quality index can be estimated based on various water quality parameter changes with time and location. The WQI is indicating the multifarious water quality analysis

that means it shows the water is an acceptable limit and usable limit by all the water bodies. The quality of water cannot be determined by any single number like Water Quality Index (WQI), it is required to include all the important parameters for as indicator the quality of water[6,7].

Generally, the water quality index analysis is incorporated with various physicochemical parameters of water by using a mathematical expression which indicates the favorable of a water body with its evacuated number.

Due to the fast growth of the nation, it has led to various water treatment processes available like RO, ED, ion exchange, and solar desalination. Among them, solar desalination is the most economical and eco-friendly process concerning the existing conventional water purification process. The existing processes are more rating energy-intensive uneconomical and provide an unfavorable effect on the environment load. The nation is also facing the crisis of energy supply which is used in these technologies is also inadequate[8,9].

The solar desalination process is the best solution for daily operation and it can especially use in remote and small communities in many arid regions with a lack of awareness about technology for the purification of water. Due to the fast increasing population and the same way more water demand of those regions, the limited water resources regularly get brackish or contaminated.

The principle motivation behind this examination is to make water accessible in those regions that have restricted assets of freshwater; it gives dependable, safe gracefully of water to growing communities. And also to an analysis of water quality parameters of the Gomti River and distilled water. After that, the analyzed water quality index with the help of a weighted arithmetic method (WAM) of all changes of physicochemical parameters of the water with time and obtained data comprised of water quality standards such as WHO and BIS.

The quality of water rating value for different parameter Q_n canestimate by the following equation[10].

$$Q_n = \left({}^{C_n}\!/\!_{S_n} \right) \times 100 \quad (1)$$

where Q_n is the quality rating scale for the n-th water quality parameter, C_n is the concentrationin the n-th water sample, S_n is the standard acceptable limit of the n-th parameter, and the result multiplied by 100. The relative weight can be estimated by the following expression as:

$$W_n = \frac{1}{S_n} \quad (2)$$

where W_n is the relative weight, which is inversely proportional to the S_n value of the different environment parameters of water.

Finally, the value of WQI can be estimated with the help of Q_n and W_n expression.

$$\mathrm{WQI} = \left(\sum W_n Q_n \right) \quad (3)$$

In general cases, the OWQI was used for a particular and intended reason for the water. But in our study, we have considered the permissible value of potable water is 100, so we can calculate the QWQI by the following mathematical expression as:

$$\mathrm{OWQI} = \left(\sum W_n Q_n \right) / \sum W_n \quad (4)$$

The quality of water was categorized by using WQI value into the following five classes as shown in Table 1[11].

Table 1. Classification of water quality based on WQI value

WQI level	Water quality
0–25	Excellent
26–50	Good
51–75	Poor
76–100	Very poor
>100	Not acceptable

Materials and methods

Study area and sampling points:

River Gomti is a branch of the holy River Ganga is an important river of Uttar Pradesh and is the lifeline of the capital Lucknow. River Gomti also called Adi Ganga is the daughter of Sage Vashisth. It originates at the near of Madhotaal (PhoolarJheel), Pilibhit, India. The river contributes about 15% of the flow of River Ganga. River Gomti has an average dry weather flow of 1500 MLD, while in monsoon season the flow becomes very as high as 55000 MLD and in summer as

low as 500 MLD. River Gomti has an effective area of about 25,735 sq. km. Its flow mainly depends upon the occurrence of rain and therefore the flow in the river is very lenient during monsoon[12,13].

For the conduction of the experimental work, we have collected 5 samples from different location sites as shown in Fig. 1: Gaughat (S-1), Mohan meakins (S-2), Hanuman setu (S-3), Kukrail (S-4), and Barrage (S-5). The experiment has been conducted from February 2017 to March 2017.

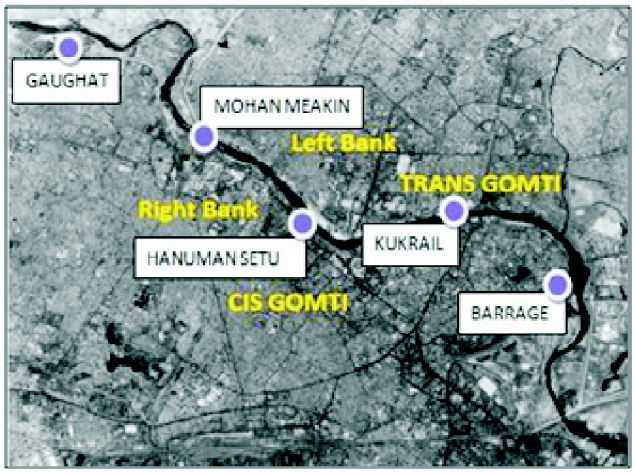

Fig. 1. Map showing sampling location sites.

Construction of solar distillation unit:

Our modified experimental setup has been fabricated using materials such as transparent acrylic sheet, FRP (fiber-reinforced plastic) sheet as shown in Fig. 2. The 3 walls still have been replaced by an acrylic sheet (3.0 mm thickness) instead of FRP (5.0 mm thickness) sheet because it has more durability, high thermal conductivity, light-weighted. The purpose of this modification was to capture diffused radiation also. That's why we have replaced the FRP with the transparent Acrylic sheet. Fortunately, we got better output by using this additional diffused radiation. In our case, we have used the surface area of the top inner glass surface (which is in direct contact with the vapor). Only the north wall and base surface are made by FRP sheet material. The inner solar basin area has been considered with dimension as 2.0 m×1.0 m×0.01 m. For more and better absorption, painted black colour with resin over the bottom surface (inner) of the still basin. For enhancing the performance and yield of the system, it was installed in the East-West direction for maximum absorption of solar radiation and gradually increased inside the temperature of the still. For better condensation, we have considered the depth of the still's are 0.12 m at ends sections, 0.48 m at the centre section. Two simple window glasses are used to cover the top surface of solar still with a dimension of 1.03 m×1.06 m× 0.004 m. The inclination angle of glasses has been considered as 15° for more collection of distillate as product water[14,15].

For experimentation, the solar still basin was initially filled with contaminated water as feed water up to 0.01 m depth (approx. 25 liters). The evaporation and condensation processes are started and then the product water (distillate) is collected by V-shaped drainage areas, which are fitted below the glass covers lower part on the walls of the solar still. The condensed water accumulated on the walls and it continuously collected in the measuring jar thorough PVC pipes. For the measurement of temperature at different points such as glass surface (inside and outside), a bottom surface, all sidewalls, water condensate, etc. in the solar still are used thermocouples (T-type)[16].

All temperatures values show in the temperature indicator device, which was operated with a solar PV panel. Solar intensity is measured by the solar power meter. For the removal of heat losses, we have used thermocol at the bottom surface of the solar still.

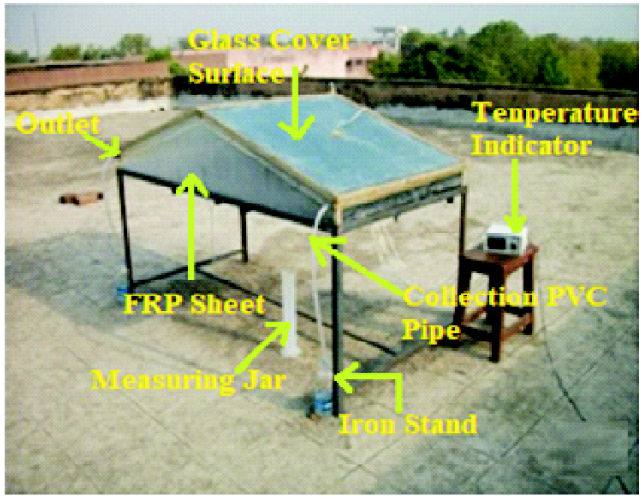

Fig. 2. Pictorial diagram of MDSSS.

Results and discussion

WQI is the most important parameter for assessing the quality of water. The various physicochemical parameters of Gomti River raw water (before the solar distillation process) at different sampling locations and mathematically estimated. The water quality index (WQI) was found before the solar desalination process as 48.52, 63.04, 43.65, 47.01, and 57.30 with water samples such as S-1, S-2, S-3, S-4, and S-5, respectively. Therefore, S-2 and S-5 indicate the poor quality of water because the river water is polluted generally from the sewage of saline due to drainage, sewage, and industrial discharge in the river. After analysis of WQI, it is cleared that the quality of water is eutrophic nature and it is not suitable for different water body activities that means need to improve the quality of water[17]. But after treatment with modified double slope solar still (MDSSS), the water quality index (WQI) was found as 21.60, 27.03, 19.45, 24.70, and 27.02 with water samples such as S-1, S-2, S-3, S-4, and S-5, respectively. Therefore, S-1 and S-3 indicate the excellent quality of water and others found within the limit as shown in Fig. 3.

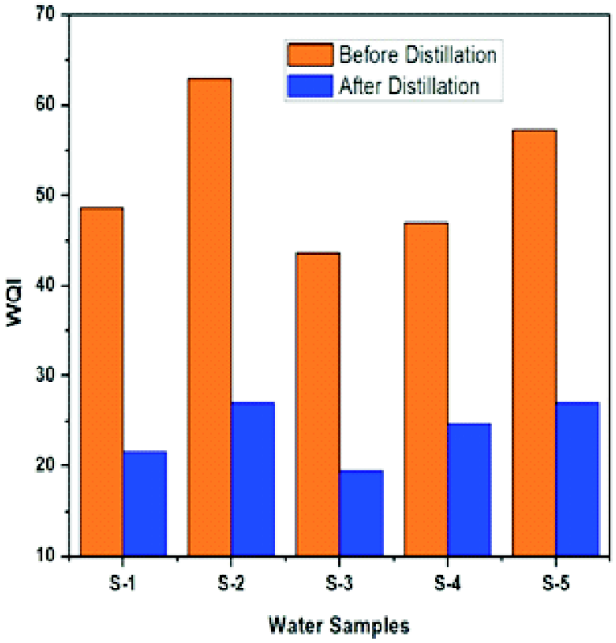

Fig. 3. WQI at before and after distillation.

According to result analysis, we found reveal exceeding the values of BOD, Total Hardness, pH, and Alkalinity with the standard value. However, the value of DO is very good. The concentration of DO is responsible for the division of *flora* and *fauna* in the water body. The concentration of DO range varies from 4.93 mg/L–7.50 mg/L in this study. The BOD value is indicating the organic load in the water body that means the water body is eutrophic. The concentration of the BOD range varies from 6.50 mg/L–6.98 mg/L. That means the water treatment is necessary before it is sent into the water body. The TDS are shows by the amount of residue remains when a water sample has been evaporated to dryness and its range varied from 342 mg/L–891 mg/L. The obtained pH range varies from 7.15–8.97 with each sample. The EC, TSS, and chlorides were also found to be very high due to more directly drainage municipal wastage into the river and these concentrations changed with seasonally as in during summer season is high as compared to the winter season and rainy seasons[18,19].

Performance evaluation of MDSSS is done based on experimental study. Samples for summer season and climatic conditions (26°84′N, 80°94′E) of Lucknow city (Uttar Pradesh), India as well as water depth are collected for 12 h during the day. The experimental observations were taken from morning 07:00 am to evening 19:00 pm. The data that we obtained from the experiment are presented here in the form of Fig. 4 and Fig. 6 among different parameters like global radiation, ambient temperature, hourly and cumulative productivity.

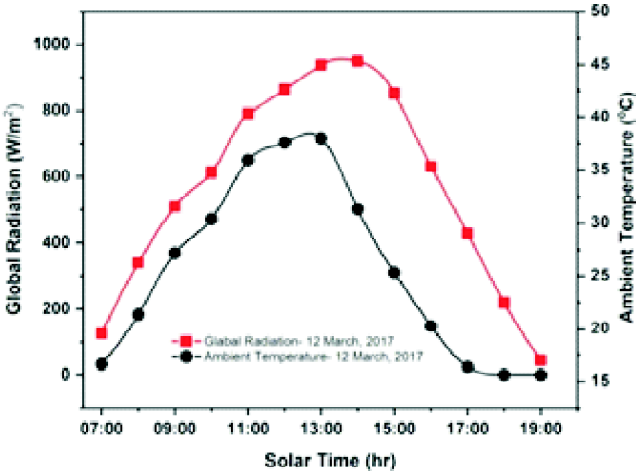

Fig. 4. Variation (hourly) of global radiation and ambient temperature versus solar time.

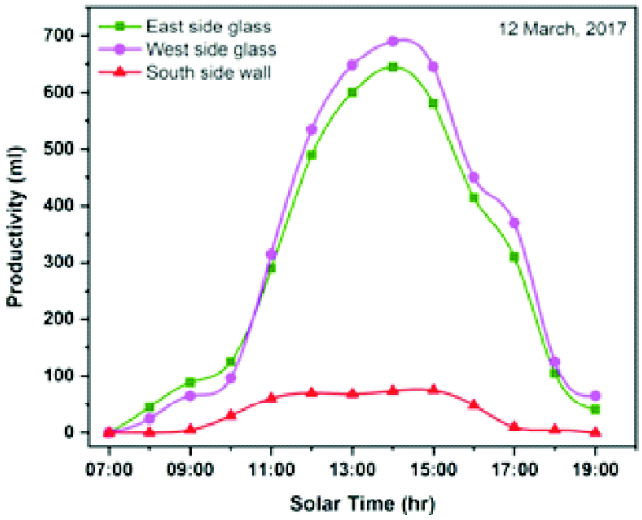

Fig. 5. Variation (hourly) of various productivities versus solar time.

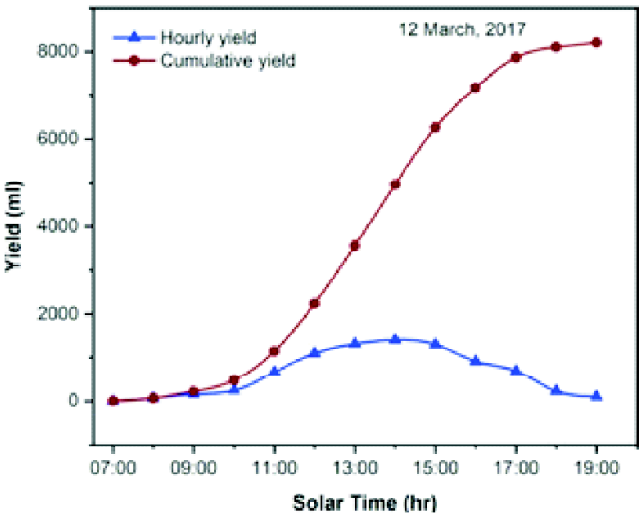

Fig. 6. Variation (hourly) of yield and cumulative yield versus solar time.

The maximum solar radiation measured was 950 W/m^2 and maximum ambient temperature was found 48.3°C at 14:00 pm on 12 March 2017. The maximum East side and West side productivities have been found as 645 ml/h and 690 ml/h at 14:00 h, respectively while at South wall has also been found as 75 ml/h at 15:00 h. The maximum hourly yield and maximum cumulative yields were found 1409 ml/h 14:00 h and 8209 ml/day, respectively.

Conclusion

In conclusion, various water quality parameters are estimated (both raw and distilled water) with the different method as water testing kit, analytical procedures, and then water quality index estimated with help of weighted arithmetic method (WAM) reveals that the quality of Gomti River water is the more deteriorating condition at the entering into Lucknow city.

Because of that, it polluted due to the discharge of sewage, drainage, and industrial waste directly into the river. The water quality was fairly at some sampling locations (Gaughat and Mohan meakins) and found that the water was polluted by industrial discharge and municipal wastage. According to the result, the raw water of the Gomti River is not directly useful for public consumption. So the government should be a scientifically planned for waste management and also take the strong action against the releasing or discarding of drainage and sewage directly into the river and also required to install a water purification system like STPs.

Finally, after the solar distillation process, the quality of water has been found favorable and within the acceptable limit as per the standardization of water quality. So, we can say that water scarcity problems can solve. This technique is most suitable in especially coastal and arid areas where electricity is not available.

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