Research & Reviews: Journal of Chemistry

e-ISSN: 2319-9849

Effect of Water Pollution on Life, its Future Aspects and Remedies: An Overview

Jeevan Kunwar Chouhan*, Shipra Bhardwaj

Department of Chemistry, MLS University, Udaipur, Rajasthan, India

Research Article

Received: 19-Apr-2022, Manuscript No. JCHEM-22-61259; **Editor assigned:** 22-Apr-2022, PreQC No. JCHEM-22-61259 (PQ); **Reviewed:** 09-May-2022, QC No. JCHEM-22-61259; **Revised:** 20-Jun-2022, Manuscript No. JCHEM-22-61259 (R); **Published:** 28-Jun-2022, DOI: 10.4172/2319-9849.11.7.007

***For Correspondence :** Jeevan Kunwar Chouhan, Department of Chemistry, MLS University, Udaipur, Rajasthan, India, Tel: 9079374938;

Email: jeevan.chouhan34@gmail.com

Keywords: Dyes; Photocatalyst; Pollution sources; Water pollution; Water pollution treatment methods

ABSTRACT

We, as humans are blessed with many natural resources to survive on earth. Water is one of such resource which is very essential for life. Water pollution is a worldwide emerging issue. It gets contaminated by various sources such as overcrowding, sewage, industrialization, urbanization etc. In recent years it has become a necessity to control and manage water pollution so that clean water may be made available for us and for future generations. There are many methods available for treatment of contaminated water, such as coagulation, precipitation, filtration, ion exchange, photo catalysis etc. Photo-catalysis belongs to advanced oxidation process which is particularly designed to remove organic materials from wastewater. Various photocatalyst containing Pb metal atoms as one component and oxide as other specifically are thus discussed herein.

INTRODUCTION

Water is an important natural resource for living being all over the globe. Water pollution may be defined as alteration in the physical, chemical and biological characteristics of water which may cause harmful effects on human and aquatic life. Nearly 80% of the waste water is dumped–largely untreated- back into the environment, polluting rivers, lakes and oceans. Varjani, et al. stated that rapid progress in industrialization in last few years has increased discharge of pollutants into

environment. Discarding wastes into water bodies thus causes water pollution at massive scale. Water pollution is measured by various methods as BOD, COD, DO, pH etc. Owa carried out a research under the title "water pollution: sources, effects, control and management". He described that factors such as agricultural practices and industrialization had contributed to the water pollution and had adversely affected the quality of water. Water pollution sources, effects, control and water pollution management was also discussed. Water pollution is caused by various factors, such as - high population density, sewage leakage, industrialization, agricultural waste, pesticides, herbicides and fertilizers, animal waste, poor management, deforestation, oil spillage etc [1].

Thus above factors are considered in the present review. Pollution causing factors are described one by one and various conventional as well as advance methods are studied extensively which may help the removal of pollutants from environment like water, air, soil etc. and make the globe pollution free, that being need of the hour [2].

MATERIALS AND METHODS

Pollution causing factors

High population density: Water pollution is generally induced by various human activities and population density enhances it. As population grows, consumption increases which imposes scarcity of potable water. Further, various human activities add unwanted materials to the environment and so to the natural resources especially to water [3]. Eguabar explained worsening of water pollution due to overcrowding in urban areas. Chamara, et al. evaluated the correlation between the growth rate of population in a watershed area and effect on water quality parameters of a river ecosystem. They quantified the ideal range of population density for a watershed to maintain the quality of water at an appropriate level. They selected The Kelani River, Sri Lanka, for the survey and the study. The highest correlation coefficients of 0.7, 0.69, 0.69 ($p < 0.01$) corresponding to Biochemical Oxygen Demand (BOD), Dissolved Oxygen (DO) and Total Coliform (TC) were obtained with the population in watersheds of the river. They concluded that the population density should be approximately less than 2375 to keep the water quality in the watershed for bathing and drinking purposes and approximately less than 2672 for fish and other aquatic organisms [4].

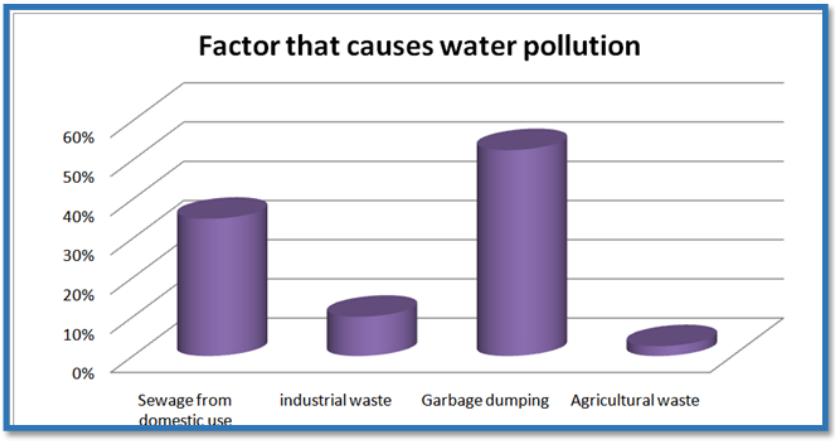
Sewage leakage: Sometimes water is polluted due to leakage of sewage water which may be caused by any accident, poor quality work or by any natural disaster. Urbanization of different area demanded proper sewage management. Thus came in existence use of various manufactured materials. Due to lacuna in their making, leakage in these materials is observed many times. Dwivedi, et al. explained that amongst all sources of water pollution, municipal sewage is the major contributor in polluting the predicament of the of the Ganga river. Ganga covers area of almost 29 large cities which have almost population greater than 1 million [5]. This entire population dumps sewage effluents into the river resulting in the poor water quality by polluting it. According to reports of 2009 central pollution control board, higher microbial counts in drinking and bathing water was observed.

Industrialization: With increase in population, urbanization and in need of development a new era of industrialization started and became the need of the hour gradually. This then started adding the discards to the environment. Rajput, et al. stated that uncontrolled disposal of untreated industrial waste imposes bad impact on local natural resources. Pesticides, chemicals, waste oil and heavy metals are regularly disposed into water which contaminates the water to a higher extent. Karunasagr drew attention towards mercury contamination due to waste effluents from a thermometer factory in Kodaikkanal, India [6]. This study assessed the level of mercury in waters, sediment and fish samples and compared the values with those from two other lakes, Berijam and Kukkal. Total mercury (HgT) of 356–465 ngl^{-1} and 50 ngl^{-1} of mercury

in methyl mercury form were seen in Kodai water. Kodai sediment showed 276–350 mg/kg HgT with about 6% methyl mercury. Berijam and Kukkal sediments showed HgT of 189–226 mg/kg and 85–91 mg/kg and lower methylation at 3–4% and 2%, respectively. Rajaram, et al. pointed out some cases like that of Tiruppur and Plachimada and concluded that specific discharge standards is the solution and local communities must contribute to safeguard their resources.

Agricultural waste: Agriculture and growing crops has been an essential activity for all living beings since the life took place on earth. As growth in population started, need of vegetation and crop increased. This forced the use of synthetic methods like manures, pesticides etc and their excessive use started release of these into natural resources especially into water. Agamuthu studied that agricultural waste is the residue of agricultural products such as crops, poultry, fruits, vegetables etc. whose economic value is less than the cost of processing it for use [7]. Thus removal of such residues from environmental resources becomes more difficult. The agricultural waste depends upon the type of agricultural activities carried out. Dien, et al. reported that disposal of empty bottles and packages of pesticides, which are thrown into water, are one of the causes that are polluting water. Plant protection department estimated that about 1.8% of chemicals remain in such packaging materials. Kumar, et al. studied the pollution caused by agricultural burning and possible alternative use of crop stubble. They explained that Straw carbon, nitrogen and sulphur are completely burnt and released into the atmosphere in the process of burning which results as the emission of smoke, if added to the gases present in the air like methane, nitrogen oxide and ammonia and it can cause severe atmospheric pollution [8]. They concluded that if the crop residue is burnt, the existing minerals present in the soil get destroyed adversely affecting the cultivation of the next crop (Figure 1).

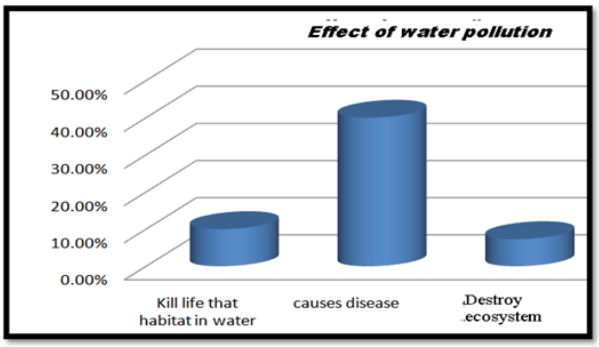
Figure 1. Causes of water pollution.



Effect of water pollution: Polluted water when used has many adverse effects on health of human, plants and animals. Aquatic life cannot sustain in polluted water. Further, it remains of no use for the domestic purpose as well (Figure 2).

Haldar, et al. reported that local communities near Turag river are suffering from various health problems which may be related to water of the river that is polluted. The study provided evidences that health problem like diarrhea, dysentery, skin problems, respiratory illness, anemia, yellow fever, cholera, dengue, pregnancy complication etc. are resulting from intake of polluted water of Turag River in Bangladesh [9].

Figure 2. Effects of water pollution.



Thus need of the hour is to make water free of pollution and a number of processes are now being undertaken to do so. After determining type of pollutants present in water it is required to eliminate such contaminating factors from the water bodies. For this, treatment methods which are easy to execute, less expensive, simple to handle, very effective and should not discharge secondary pollutants are preferred.

Some conventional methods available for removal of pollutants from water bodies

Normally some dissolved, suspended or coagulated impurities are removed, by following conventional methods, from water and are used till date. Some such methods are:

- Coagulation/flocculation
- Precipitation
- Filtration
- Adsorption
- Solvent extraction
- Membrane separation
- Ion exchange
- Photo catalysis etc.

An attempt in the study is made to review such methods of removal of pollutants from water specially colored ones *i.e.* dyes that are released generally by textile industry industries into water polluting it.

Most of the water bodies have suspended colloidal particle making the water turbid that is one of reasons causing pollution [10]. Bratby proposed various advantages of coagulation method to treat such water sources. It was stated that the process is superior as it is inexpensive, rapid in treatment and is efficient for insoluble contaminants. The method was also preferred as wide ranges of chemicals are available to employ the process for treatment of polluted water. Further, the process does not add any other material to water.

Yen-Yie, et al. reported the degradation of methylene blue and methyl orange dyes by coagulation method using Laterite soil dominated by silica component. They used charge neutralization, electrical double layer compression and sweeping flocculation as the mechanism in the decolorizing reaction. The degradation of methylene blue and methyl orange into smaller molecules of hydrocarbon along with formation of silsesquioxane were reported in this study [11].

Moghaddam et al. studied dye degradation enhanced by decreasing pH which does not re-establish if the amount of sludge increases. They concluded that reusing the ferric chloride sludge as a low-cost material into the coagulation/flocculation

process in wastewater treatment plants can offer some advantages such as high efficiency for acid red 119 dye removal and economic savings on overall treatment plant operation costs.

Another simple process, in which saturated solution of any compound is treated to obtain solid, is termed as precipitation [12]. Silva, et al. studied the degradation of methylene blue by using an oxidant Mn_3O_4. They synthesized discrete Mn_3O_4 particles and Mn_3O_4/Fe_3O_4 nano-composites *via* co-precipitation by using air as an oxidant in the absence and presence of previously synthesized magnetite nanoparticles, respectively. They applied this nano-composite in the oxidative decolonization of methylene blue and this catalyzes the N-demethylation of methylene blue and forms thionine as the final product [13,14].

Chen, et al. stated that precipitation method was considered as a cheaper, simple method that reduced the COD of water up to a significant level. They concluded that prepared photo-catalytic membrane degraded dye molecules and separated oil-water emulsion under visible light. This membrane showed excellent antifouling capacity and recyclability. Zhu et al. suggested the degradation of acid blue 80. It was done by using alkaline white mud with degradation efficiency up to 95%. According to Chakraborty, et al. filtration is a simple and efficient method. There are many filtration techniques available such as microfiltration, ultrafiltration, nanofiltration etc. Cheng et al. stated that reduced graphene oxide-TiO_2 nanomaterial is counterfeited with simple vacuum filtration which degrades the dye. This combination had large surface area, flexible structure, mobility of charge carriers and high conductivity.

In Microfiltration, a contaminated fluid is passed through a special pore-sized membrane to separate microorganisms and suspended particles from process liquid. It is a pressure-driven separation process widely used in concentrating, purifying or separating macromolecules, colloids and suspended particles from solution. Further, ultrafiltration can be explained as a variety of membrane filtration in which forces like pressure or concentration gradients lead to a separation through a semi-permeable membrane [15]. It is similar to reverse osmosis and an effective method of reducing the silt density index of water and removing particulates that can foul reverse osmosis membranes. Nano filtration is another pressure driven membrane filtration process. This technique is a popular way to remove organic matter, color, odor, residual quantities of disinfectants and trace herbicides from large water body [16].

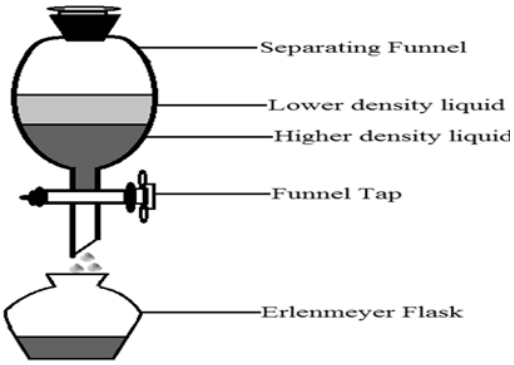
Effluents of textile industries contain pollutants mainly dyes. Such pollutants can be treated by adsorption process. Henze, et al. explained that dye from water can be removed by biodegradation. Active microorganisms are used for this purpose that has two functions:

- Adsorption on the surface of the substance
- Degradation of dyes which is done by enzyme produced by these microorganism.

Pirok, et al. discussed some advantages of this process such as well accepted by public, large number of species available, inexpensive etc.

Compounds may be separated from water on the basis of their relative solubilities in two different solvents under solvent extraction technique. Two solvents- one polar and other non-polar are used for this purpose. Crini explained the use of DMSO and acetonitrile (non polar solvent) and water (Polar solvent) to remove Eosin and Carminic acid dyes from polluted water. Pandit, et al. suggested a new technique based on liquid/liquid extraction using reverse micelles whereby recovery of solvent and reuse of dye is possible. They explained that the ratio of solvent to aqueous phase volume required for the removal of dye decreases with the increase in surfactant concentration [17]. They concluded that the separation of aqueous phase from the aqueous-phase solvent dispersion is faster for amyl alcohol as compared to benzyl alcohol and methyl benzoate (Figure 3).

Figure 3. Solvent extraction apparatus.



Membrane separation technique and another technique, is useful and well known to recycle and to reuse the treated wastewater. Here membranes of different materials and of different sieve size are used to filter water. These sieve size can be in microns. Choi, et al. stated that this technique is prominent for selectively separating the components of various particle size and molecular mass. It may be specified that some membranes are selective towards materials and so allow passage of some materials. Santos, et al. studied Cr^{3+} embedded on geo polymer membrane and crystallizing it in situ. This was then as hybrid photo catalyst to treat dye waste water. Prihodko, et al. studied the effect of surface acidity, nature and dispersion of iron species, controlled by the catalyst preparation technique on the catalytic wet peroxide oxidation of Rhodamine G dye over the Fe-ZSM-5.

Ion exchange technique, one of the pollutants removing technique, is a method in which unwanted ions are replaced by other non-contaminating ions. Ansari, et al. studied the effectiveness of Polyaniline-Cl^- Polyaniline-ClO_4^- and Polyaniline-SO_4^{2-} ClO^- on removal of nitrate in a dual cell reactor and for safety measures electrically switching ion-exchange approach was employed. Vithal, et al. prepared nano sized Cu^{2+} and Ag^+ doped $Na_2Ti_3O_7$ by a facile acid free ion exchange method in an aqueous solution at room temperature. This was then further used to degrade blue dye in waste water effluent. They also examined visible light-induced photo catalytic oxidation of the Methylene Blue (MB) dye [18].

Besides all these purification and cleaning methods, it was observed that advanced oxidation process has enormous potential in removal of pollutants. It also has some other benefits like it does not add any other chemicals to the environment, formation of a free radical chain reaction occurs that runs spontaneously further and does not need any other efforts etc. Speeding up a reaction in presence of light and catalyst is known as photo catalysis. This occurs by absorbing photons of light and converts contaminants into harmless substances. Photocatalysis is considered as an advanced oxidation process and now-a-days is extensively used in various fields like for purification of environmental factors, hydrogen production, degradation of pollutants, in solar cells etc. Thus, removal of colored pollutants from industrial effluents is also considered in order to obtain clean and pollutant free water to be used for other purposes like cleaning, washing, cooling etc. Potability of this treated water is other aspect to be researched. Mohammad, et al. proposed photo degradation of Congo red dye with pure Cu_2O, Cu_2O/TiO_2 and Cu_2O/ZnO. They described a facile one pot solvo-thermal method of synthesis of these compounds as solvent and reducing agents.

Mohammad, et al. explored floating photo catalyst as potential candidate for wastewater treatment. They further added that this system can overcome the drawbacks posed by the suspended TiO_2 photocatalysis system. The degradation of methylene blue dye was done by TiO_2 and polyvinyl alcohol in the ratio of 1:8 under visible light. Grao, et al. used immobilized TiO_2 on stainless steel mesh as photocatalyst. They studied five independent variables-UV light intensity,

number of TiO_2-coated mesh layers, coating thickness, water flow rate and initial dye concentration.

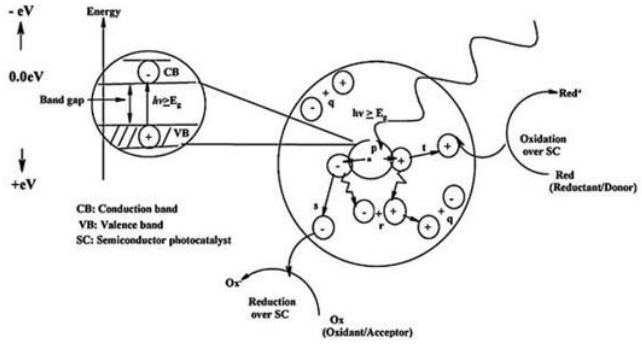
RESULTS AND DISCUSSION

Roonasi synthesized barium ferrite/activated carbon composite as an effective solar photocatalyst for discoloration of organic dye contaminants in wastewater. In this study various parameters *viz.* temperature, amount of catalyst, irradiation intensity and reusability of photocatalyst that affects the discoloration of organic dyes etc. were considered.

It was observed that method of synthesis of any photocatalyst plays an important role in its activity and efficiency of working on to any pollutant. In order to prepare a suitable photocatalysts for organic dye degradations, various techniques and methods have been develops. Numerous methods such as sol-gel auto combustion process, homogeneous hydrolysis, ultrasonic technique, co-precipitation technique etc. were used for this purpose. Some doped materials were also used for degradation like Mn doped and PVP capped ZnO nanoparticles, Iridium doped ZnO, 3D flower like F-doped titanium dioxide bronze (F- TiO_2 (B)), F-doped titanium dioxide bronze fullerene (F-TiO_2 (B)/fullerene), cobalt doped nanotitania photo catalytic system etc. Nihalani, et al. carried-out degradation of P-Rosaline hydrochloride using barium tungstate as photocatalyst.

Further, mechanism of the overall degradation process was also ascertained in order to obtain the and also to get a route to improve and to enhance the speed and quality through which a photocatalyst works on a pollutant. Mills, et al. studied that photcatalytic dye degradation is a photo induced reaction which is accelerated by the presence of photcatalysts. Carp, et al. reported that these reactions are activated by absorption of photon of energy equal to or higher than band gap energy of the photocatalyst. It was stated that during the photocatalysis the continuous consumption of hydroxyl radicals requires replenishment which is needed to maintain catalytic activity. Photocatalytic oxidation has been reported to be more cost-effective than incineration or bio-filtration for flow rates up to 20,000 cfm (ft^3/min) for treating a 500 ppm volatile organic compound laden stream (Figure 4).

Figure 4. Schematic diagram of photo catalytic process initiated by photon acting on the semiconductor·



Konstantinou, et al. explained that the electron accelerates from valence band of semiconductor to the conduction band generates a hole in valence band. The photo generated holes can oxidize the organic molecule to form R+, or react with OH^- or H_2O oxidizing them into OH• radicals. The resulting OH• radical, being a very strong oxidizing agent (standard redox potential+2.8 V) can oxidize most azo dyes to the mineral end-products.

The electro catalytic oxidation of o-nitrophenol (o-NP), m-nitrophenol (m-NP) and p-nitrophenol (p-NP) was studied by Liu, et al. with Bi-doped lead dioxide anodes on acid medium by cyclic voltammetry and bulk electrolysis.

Control and management of water pollution

It is observed through the review that all the pollutants can pollute water directly or indirectly. Thus the study was concluded with a survey on control and management of water pollution. Numerous approaches can be adopted for controlling and managing water pollution such as prevention, regulation and monitoring the control measures, starting a project or program etc.

Alguraja, et al. reported remote sensing and GIS approach for water pollution and management in Tiruchirappali Taluk, Tamilnadu in India. They said that demarcating the administrative division of the study area by preparing various thematic layers in the block and remote sensing study through IRS-1D LISS 111 satellite imagery and SRTM data must be employed.

Sing, et al. studied water pollution, its sources, effects and control. They listed all the control measures taken into action by the government and NGO's. Olmstead, et al. reviewed water pollution control in developing countries, policy instruments and empirical evidence. They described a range of prescriptive and marked based regulation, voluntary programs and other policy instruments to control water pollution. Manjula, et al. studied the ground water pollution in India and the laws related to it. They explained Act 1974 for controlling water pollution, its limited scope and lack of agreement. The law was fount inadequate for implementation of some simple solution such as reverse osmosis etc.

CONCLUSION

It is concluded here by that about 71% of the earth surface is water covered and 96.5% of it is hold by oceans. Only 3% of the earth's water is fresh and potable. Around 70% of the industrial waste is dumped into water and 80% of the water pollution is caused due to domestic sewage. Various human activities pollute water on a large scale. Water pollution has bad impact on human health and aquatic lives. Now-a-days scientists have started directing their research towards this issue. Numerous treatment methods are thus developed such as filtration. Coagulation, ion exchange, precipitation, adsorption, photocatalysis etc. to resolve this issue. These methods help in cleaning and purifying water and this treated water can be used in industries, agricultural tasks etc. Further, more treatments are required to make water to be used for drinking purpose. Photocatalysts that are being used to degrade pollutants present in water are considered as best pollution removing agents. Some dye molecules get adsorbed onto the surface of photocatalyst by electrostatic attraction and get mineralized by non-selective free radicals. Therefore, the adsorption of the target molecule on photocatalyst surface may be regarded as a critical step toward efficient photocatalysis and may remove the pollutants completely leaving behind clean water for further use.

DECLARATION

No funding was received for conducting this study.
No funds, grants, or other support was received.
Authors have no relevant financial or non-financial interests to disclose.

REFERENCES

1. Varjani SJ, et al. Critical review on bio surfactant analysis, purification and characterization using rhamnolipid as a

model biosurfactant. Bioresour Technol. 2017;232:389-397.
2. Owa FW, et al. Water pollution: sources, effects, control and management. Int Lett Nat Sci. 2014;3:1-6.
3. Olmstead S, et al. Water Pollution Control in Developing Countries: Policy Instruments and Empirical Evidence. Rev En Eco Pol. 2021;15:261-280.
4. Liyanage CP, et al. Impact of population growth on the water quality of natural water bodies. Sustainability. 2017;9:1405.
5. Dwivedi S, et al. Ganga water pollution: a potential health threat to inhabitants of Ganga basin. Env Int. 2018;117:327-338.
6. Rajput RS, et al. Status of water pollution in relation to industrialization in Rajasthan. Rev Env Health. 2017;32:245-252.
7. Karunasagar D, et al. Studies of mercury pollution in a lake due to a thermometer factory situated in a tourist resort: Kodaikkanal. India Env Poll. 2006;143:153-158.
8. Rajaram T, et al. Water pollution by industrial effluents in India: discharge scenarios and case for participatory ecosystem specific local regulation. Futures. 2008;40:56-69.
9. Kumar P, et al. Pollution caused by agricultural waste burning and possible alternate uses of crop stubble: a case study of Punjab. Springer, Berlin, Heidelberg, Bangalore, India. 2013;1-371.
10. Ladu JLC, et al. Investigation on the impact of water pollution on human health in Juba County, Republic of South Sudan. J Env Poll Human Health. 2018;6:89-95.
11. Halder JN, et al. Water pollution and its impact on the human health. J Env Human. 2015;2:36-46.
12. Khan N, et al. Physicochemical investigation of the drinking water sources from Mardan, Khyber Pakhtunkhwa, Pakistan. Int J Phy Sc. 2013;8:1661-1671.
13. Bratby J, et al. Coagulation and flocculation in water and wastewater treatment. (3rd edition). IWA publishing, London, UK. 2016;1-525.
14. Lau YY, et al. Degradation of cationic and anionic dyes in coagulation–flocculation process using bi-functionalized silica hybrid with aluminum-ferric as auxiliary agent. RSC Advances. 2015;5:34206-34215.
15. Moghaddam SS, et al. Coagulation/flocculation process for dye removal using sludge from water treatment plant: optimization through response surface methodology. J Haz Mat. 2010;175:651-657.
16. Silva GC, et al. A facile synthesis of Mn_3O_4/Fe_3O_4 super paramagnetic nanocomposites by chemical precipitation: Characterization and application in dye degradation. Mat Res Bull. 2014;49:544-551.
17. Chen Q, et al. A novel photocatalytic membrane decorated with RGO-Ag-TiO_2 for dye degradation and oil–water emulsion separation. J Chem Tech and Biotech. 2018;93:761-775.
18. Zhu MX, et al. Removal of an anionic dye by adsorption/precipitation processes using alkaline white mud. J Haz Mat. 2007;149:735-741.