Methods of Reducing the Fate and Transport of Nutrients from Agricultural Fields

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ABSTRACT— ***Control of pollutant loading is an important issue with respect to environmental conservation, and the loading of nitrogen and phosphorus from agricultural areas is well known to be a major contributor to the accelerated eutrophication of rivers and lakes which lead to harm human health. Also, leaching is the main cause of chemical losses from surface to sub-surface. Thus, it is vital to understand nutrient leaching from paddy fields. From the reviewed literature, there is a need to reduce the fate and transport of agro-chemicals from agricultural fields particularly from paddy fields. However, nutrient loss through surface and sub-surface drainage could be achieved by adapting several techniques, this includes: water-saving system (WSI), drainage control (DC), and recycling irrigation system (RI).***

Keywords— Nutrients, Water-saving irrigation, drainage control, cycling irrigation, Agro-chemicals.

1 INTRODUCTION

Water is one amongst the foremost vital inputs to agriculture. However, the agricultural sectors are expected to receive a reduced water allocation despite the increasing pressure for a lot of food production [1]. Together, the increasing food demand and decreasing water allocation counsel that the agricultural sector needs to turn out a lot of food with less water, that's to extend agricultural water productivity [2]. To satisfy the rising food demand that may occur as results of increasing population and ever-changing dietary patterns, the globe has to guarantee property land and water productivity enhancements over the approaching decades [3]. The supply of fresh water in agriculture is decreasing and thus, there's a necessity to develop a a lot of economical water system in agriculture. This is often a lot of proof for rice production with the next water use for economical production. Certainly one of the possibilities to extend the rice production using the restricted water resource is to develop a new water saving system for rice production [4]. However, numerous water-saving irrigation systems are used, among them; Intermittent Irrigation (II) is taken into account to be one of the foremost promising technologies [5 and 6].

Zhang and Xue [7] stated that intermittent irrigation (II) was the irrigation technique that saved the foremost water, and frequent irrigation saved the smallest amount. Anbumozi et al. [5] found that rice yields may be lower under intermittent irrigation than continuous flooded irrigation (FI), however intermittent irrigation might considerably improve water use potency. Standard irrigation management approaches together with excessive nutrient input have augmented nutrient leaching losses from agricultural lands, those results in serious pollution to each surface water and groundwater [8, 9, and 10].

Previously, submerged drainage systems were generally designed to drain water incessantly, while not relation to the environmental consequences and also the impact on crop production. This method is employed in each humid and arid area to forestall water-logging, give aeration, to make sure crop growth and enhance the traffic-ability of the soil, therefore allowing the timely soil preparation for planting and harvest [11]. This phenomenon has modified in humid areas of the globe as the environmental consequences and crop production effects are documented. Intensive row crop production is commonly targeted on increasing yields, with very little attention paid to the environmental consequences. However, to maintain high crop yields, and meet the farmer's expectation of abundment, cheap, prime quality food, fertilizer, herbicide, manure and chemical usage has inflated over the years [12]. Additionally, farmers often increase the dose in order to obtain high yield which subsequently causes groundwater pollution.

Thus, it's very crucial to find an effective way to reduce the fate and transport of agrochemicals from agricultural fields. Therefore, in this review paper, we will discuss three different methods/techniques namely Water-saving irrigation, Drainage control and recycling irrigation system for reducing solute transport from different agricultural fields.

2 WATER-SAVING IRRIGATION (WSI)

Food security in Asia, where about sixty million of the world's populations live, is challenged by increasing food demand and vulnerable by declining water accessibility [13]. With rice production throughout the continent must increase to provide an escalating population, whereas water for irrigation is obtaining scarcer. It's been calculable that 530 million tons annually rice produced globally, 90-92% is produced and consumed in Asia, wherever it provides 35-80 percent of total calorie uptake [14]. But to remain up with growth and income elicited demand for food in the majority of low income Asian nations [15], it's calculable that rice production needs to be accrued by 56 percent over following thirty years [14]. Irrigated rice accounts for concerning fifty percent of the entire quantity of water diverted for irrigation, that in its self-accounts for eighty percent of the quantity of water diverted [16]. The key factors are population growth, increasing urban and industrial demand, and decreasing accessibility owing to pollution and resource reduction [13]. However, in rice production areas, one in every of the foremost necessary concerns within the design and management of efficient irrigation projects is considered the irrigation schedule (Xu et al. 2002).

It is understood that over-fertilization could be a major drawback in intensive agricultural production areas, ultimately causing the enrichment of air, soil, and water with reactive chemical element resulting in the impairment of scheme functions. The over-fertilization entails gratuitous economic expenditure for farmers. N loss from agricultural fields is the primary reason for eutrophication. Few research reports have determined the potency of N use and loss of paddy fields using controlled release chemical element fertilizer under water saving irrigation management [18], and various studies have targeted under flooded condition [19]. The excessive N and P fertilizer use with decreasing fertilizer use efficiencies in agriculture has triggered massive amounts of N and P components coming into ambient water bodies and therefore the atmosphere through different means [20, 21, 22, 23 and 24]. Meanwhile, the transport of chemicals from paddy fields could pollute the lakes and streams that cause to damage human health. Although leaching is the main reason for chemical losses from surface to sub-surface, it's important to know nutrient leaching from paddy fields.

To be able to enhance the grain production while using the restricted water resources is to develop new water-saving rice production systems. many researchers have investigated the impact of water-save irrigation on water use potency, water productivity, and crop yield by comparing with continuous flooded irrigation [13, 25, 26 and 27]. Lu et a. [28] compared the distinction in water consumption and ice yield between Flooded irrigation (FI) and three water saving irrigation schedules (Shallow-wet irrigation, Intermittent Irrigation, and Controlled Irrigation) to spot the foremost appropriate water saving and high yield rice irrigation schedule. Their result showed that, the appliance of a sophisticated irrigation schedule not solely saved a large quantity of water for irrigation, however conjointly the rice yields weren't greatly reduced, and even augmented in Shallow-wet irrigation.

Belder et al. [25] studied the impact of water-saving irrigation on crop performance and water use by evaluating Alternately submerged-non submerged ASNS) and continuous submergence (CS). They found that water productivity was high under ASNS then under CS, while irrigation water input was 15-18% lower under ASNS than under CS. However, they suggested under water-saving irrigation system, water use reduces around 15% without getting affected yield when the shallow groundwater water stays within 30 cm. A divergent result was as outlined above by [13], they proven water saving method to save water while growing water productivity under different water management. The results showed water productivity will increase up to a most however decreases yield, which does not produce more yield with less water. However, they suggested that, total yield production might be elevated through the use of water stored in anybody to irrigate new land in another. Abbasi and Sepaskhah [4] investigated the effect of water use, rice yield and water productivity of numerous rice cultivars under intermittent flooded irrigated in comparison to continuous flooded condition.

Several studies revealed that water saving irrigation reduced nutrient leaching losses from agricultural fields, particularly paddy fields [29, 30 and 31]. Li et al. [32] mentioned that solute loss was lower under water-saving irrigation techniques compared to conventional flooding irrigation. Furthermore, various researches has determined nutrient losses from dry agricultural fields, only a couple of those involved paddy soils. Different Studies reported different results, e.g., Tian et al. [33] conducted field experiment and demonstrated that nitrate was the primary type of nitrogen in percolating water throughout the rice growing season. Simultaneously, researchers [34, 35 and 36] reported exactly the same result. However, Pathak et al. [37] reported that, ammonium nitrogen was the primary type of N leaching from paddy fields.

They demonstrated that, NO3-N, NH 4^{+}N, and organic N leaching losses taken into account 19.8, 53.9, and 26.4% from the total nitrogen during rice growing season. Ji et al. [38] carried out 2 year field experiment and indicated that ammonium nitrogen and organic nitrogen accounted 39.7% and 56.8% from the total nitrogen leaching losses from paddy fields correspondingly, which the number of nitrate nitrogen to total nitrogen was just 3.5%. However, this questionable effect can result in associated with several factors, like type of experiment (field or lysimeter type experiment), soil conditions, hydrological, fertilizer, and irrigation management factors.

The majority of the rice irrigated areas have implemented some simple seepage control projects, however they don't use advanced water saving irrigation schedules during rice planting [28], rather traditional flooding irrigation (FI) is utilized which wastes valuable water sources and fosters no rise in rice yields. There are controversial opinions among rice researchers about potential yield loss associated with reducing water use. Tuong [39] mentioned that, maintaining a higher level over the rice growth period wasn't essential to obtain high yields. De Datta [40] established that rice grain yield was highly associated with the quantity of water use. The introduction of water use efficiency through the use of less water to acquire greater grain yield was begun in early 1990's when dams gain popularity like a water management tool [41]. However, more than 75% from the grain produced originates from irrigated land. Water crisis threatens the sustainability from the irrigated system. The availability water irrigation is endangered by declining water quality, declining resource availability, elevated competition from other users, and growing costs. Rice is particularly responsive to declining water availability because it requires more water than every other food crop and contains relatively low-water use efficiency [41]. However, growing population and water for irrigation gets scarcer, the planet has become facing the difficulties in order to save water, increase its productivity, and convey more yield with less water. Bouman and Tuong [13] recommended that, water input could be reduced by reduction of ponded water depths to soil saturation. Additionally they demonstrated water productivity (WP) could be improved by presenting periods of non-submerged conditions of various days throughout the growing season cracks are formed through the plough sole.

Various water saving irrigation systems is presently adapting in paddy fields, including Intermittent irrigation (II), controlled irrigation (CI), shallow-wet irrigation (SWI), flooding-mid-season during frequent water logging with intermittent irrigation, and flooding mid-season drainage re-flooding moist intermittent irrigation but without water logging [42 and 43]. Zhu [44] compared shallow wet irrigation and flooded irrigation in paddy field experiments. They discovered that, Shallow wet irrigation could considerably reduce water consumption while increasing grain yield. Liu et al. [45] mentioned that, controlled irrigation (CI) can help to eliminate water use efficiency by 69.2% in contrast to flooded irrigation (FI), but grain yield will decline. This method (CI) is really a new rice irrigation schedule that's been put forward recently [46, 47 and 48]. In CI, the soil within the paddy field remains non-flooded, usually 60-80% of times thus, no standing water is located after re-greening of grain seedlings, except throughout the periods of harvesting rain, pesticide, and fertilizer application [49]. Additionally, controlled irrigation has been shown good at reducing irrigation input without causing yield reduction [50], and it has been broadly adopted all over the world.

Previous results have proven that the use of controlled release nitrogen fertilizer can boost the efficiency of nitrogen use and rice yield and lower nitrogen loss from paddy fields [51, 52 and 53]. It had been reported that, the concept of conventional flooding irrigation and excessive quantity of nutrient fertilizer use have elevated N losses from paddy fields and therefore have caused ecological problems. Wu et al. [54] reported that, the entire N from agricultural non-point source makes up about 37.5% from the total N discharged in to the lake. Experiments conducted demonstrated that water saving irrigation may increase $NH^{+}4$ with NO-3 concentrations in percolation water and reducing total percolation water in contrast to traditional flooding irrigation system [55]. Also, nutrient loss from paddy fields under water saving irrigation was less than that flooding irrigation [56].

Yang et al. [18] investigated the potency of water-saving irrigation and controlled release fertilizer management on nitrogen losses from paddy fields. Their results demonstrated that both controlled irrigation and controlled release nitrogen fertilizer management were good at maintaining rice yield, growing nitrogen recovery and reducing nitrogen losses from paddy fields, however, controlled release nitrogen fertilizer was more efficient, halving nitrogen loss towards the atmosphere. Peng et al. [30] conducted an experiment to examine the nitrogen and phosphorus losses from paddy fields under different fertilizer and irrigation managements (flooded irrigation and controlled irrigation systems). They found that, both P and N leaching losses were reduced within the controlled irrigation system when compared with flooded irrigation treatments under same N management. Therefore, the use of controlled fertilizer and water saving irrigation system can help to eliminate the fate and transport of chemical fertilizer losses from paddy fields. Reducing nutrient loss through surface drainage might be achieved by water-saving irrigation and minimized compelled drainage [34].

3 DRAINAGE CONTROL (DC)

Management of pollutant loading is a vital issue regarding ecological conservation, and also the loading of nitrogen and phosphorus from agricultural areas is known to become a major cause of the accelerated eutrophication of rivers and ponds [57]. Eutrophication is among the world's water quality problems, and it has become probably the most important ecological problems. Agricultural non-point source pollutions are among the important reasons water eutrophication. In agricultural production, farm owners seek high yield and unnecessary use of pesticides and fertilizers that leads agricultural non-point source pollution. Massive amount of chemical fertilizer application consumed by farmers, but only 20-50% from the nutrients used by the farmland [58 and 59]. Numerous solutes goes into the atmosphere through different processes e.g. runoff from farming fields, and deep percolation from subterranean pathways, leads to water and soil contamination and river and lake pollution.

Agricultural lands are some of the major causes of non-point pollution, because their use of chemical fertilizer through the agriculture sector is presently excessive. Non-point source pollution has the effect of a lot more loading of pollutants into many closed body water than would be the point source pollution [60]. The degeneration water quality in marine systems for Example Rivers and ponds is a problem of curiosity in lots of regions on the planet. However, pollutants discharged in the point sources happen to be controlled sufficiently compared to non-point source pollutions [61]. Wesström et al. [62] conducted 2 year experiment to evaluate impact of controlled drainage on hydrology, water quality and atmosphere. It had been reported that, in comparison the controlled drainage with conventional drainage system, the controlled drainage had a big impact on hydrological and ecological over these 2 years of experiments. They established that both nitrate and phosphorous loss were less for drainage control when compared with conventional free drainage system. Mood et al. [63] studied effect of controlled drainage on crop yield and water use efficiency through simulation of physical model, by evaluating free drainage and controlled drainage conditions. They reported that controlled drainage condition, the capillary rise water meets the plant water requirement, and yield was 3.5 times better as even compares to free drainage condition.

Xiao et al. [64] investigated solute transport in a paddy filed by establishing a multi-objective model for optimal drainage time under controlled drainage condition. Their results indicated that, the nutrient (N and P) transport were high during early period of flooding condition, and gradually decreased as the flooding lasted. Jia et al. [65] investigated the possibility of drainage control to decrease adverse consequences of drainage water in YinNan region, china. They proved that, drainage control system would lead to a reduction in effluent discharge about 94%. Kahlown et al. [66] suggested that water table depth of 1.5 to 2 meters is the optimum water table depth for most crops except sugar cane, which gave even higher yields with the water table at 2 meter depths. Asad [67] stated that high wheat yield could be obtained with 1-2 irrigations of 7.5 cm each when the water table depth was about 1-2 m. Doering et al. [68] stated that uncontrolled drainage systems were over-draining land and recommended a shallow water table concept for drainage design to reduce drainage flow. Khan et al. [69] evaluated the importance of controlled drainage control under drought condition areas in Pakistan. They recommended the application of large amounts of irrigation water in different areas of controlled zones in order to save the drought conditions. Mood et al. [63] conducted an experiment to investigate the effect of controlled drainage on water use efficiency and crop yield by maintaining water-table up to 40 cm. They stated that, controlled drainage is a useful method to enhance water use efficiency. Also, their result showed the yield of controlled drainage was 2.5 times higher than the free drainage system. Meyer et al. [70] indicated that wheat extracted up to 28% to 38% of its evapotranspiration from a water table of1 meter in a loamy soil.

Nutrients may accumulate within the root zone, and subsequently leached towards the tile drainage systems and groundwater. Nitrate nitrogen is a very common pollutant water, and it is the form and nitrogen most prone to leaching because it's an anion, and therefore not drawn to soil particles [71]. Most studies on alternation in nutrient concentrations under controlled drainage condition are restricted towards the dry crops areas with subterranean pipes. Controlled drainage involves paddy field less [69 and 72]. Only couple of research has concentrated on alternation in chemical losses in continuous flooding process [12 and 73]. Nitrate ions may inside a deep layer might be leached in to the groundwater, and may transport into streams, ponds, and rivers through subsurface drain outlets [74]. The primary factors affecting nitrogen loss from agricultural fields by leaching would be the flow water with the soil profile, and the quantity of nitrate readily available for leaching during the time of water movement [75]. Laperriere [76] demonstrated that nitrate levels more than 40mg L-1 in drains under corn, where fertilizers was applied at rates more than 200 kg N ha-1. Also, Madramootoo et al. [77] revealed that nitrate concentrations in drainage effluent from the sandy loam field, popped with potato may be as high as 40mgL-1. Lalonde et al. [12] examined impact of controlled drainage on nutrient concentration in subsurface drainage system. They compared the disposable drainage and controlled drainage water tables of 0.5 and 0.25 over the drain level. Their result demonstrated the controlled drainage was built with a huge impact on drainage discharge quantity and quality. Additionally they reported that, controlled drainage minimized the drainage discharge considerably when compared with free drainage condition.

Research on dynamics alternation in the solute transport in a continuous flooding process and determination of the perfect drainage time are essential not just for increasing the water quality, but in addition for reducing the drainage volume of water [78 and 79]. Naiman et al. [80] examined the strength of a controlled drainage technique by evaluating free drainage and controlled drainage systems. Drain water was controlled roughly 30% for controlling system in comparison with the free drainage condition. Additionally they demonstrated that during dry season, the controlled drainage eliminated the drain discharge totally, whereas the controlled drainage didn't have impact on total drained water during wet-season. Christen and Skehan [81] conducted drainage control experiment and established that the outflow salinity was proportional towards the water table depth therefore; restricting drainage output having a deep water table will minimize the salinity of drainage waters. Wahba et al. [82] evaluated the effect of doubling the drain spacing by blocking almost every other drain and modifying the drain depth by using control structures. Their result revealed that, the implementation of those measures would lead to reduced drainage flow minimizing irrigation needs with no yield reduction. Based on Ayars et al. [11] use of drainage control might also lessen the volumes and concentrations from the drainage water, due to the alteration from the flow pattern because of the ground water ponded within the drainage laterals. Jia et al. [65] Mentioned that using drainage control is the greatest management technique to prevent solute transport to surface water. However, paddy fields as the wetlands can achieve the effect of water purification by maintaining the proper water level on the surface for a certain number of days after fertilization, pest control and heavy rain. Therefore, it is vital to guide the practice of agricultural production by studying on water level control schemes, grasping the drainage opportunity and searching the controlled drainage schemes.

Control of water table is among the management processes in irrigation and drainage systems to minimize the fate and transport of nutrient along with other chemicals from agricultural fields. Studies have revealed that agricultural drainage water could have fertilizer nutrients and pesticides. Nutrients (N and P) contained in drainage outflow mainly due to the inclusion of fertilizer, which ends up from the change in land use following drainage enhancements rather of in the mere installing of drainage [83]. Smeltz et al. [84] studied the use of controlled drainage in order to reduce nitrogen transport from agricultural field using DRAINMOD-N model. They discovered that, nutrient reduction was effective when controlled drainage and nutrient management strategy were utilized in addition to each other. Evans et al. [83] compared the result of controlled drainage and free drainage systems on water quality in humid regions. They demonstrated that, within the controlled drainage system, nitrogen and phosphorus were reduced about 30% to 50% when compared with fee drainage system. By utilizing flashboard riser type water control structures, farmers can manage the soil water to improve productivity during the dry season and lower nitrate nitrogen reduction in drainage waters by 40 to 50 percent [85 and 86].

Controlled drainage continues to be recognized in certain states because the best management practices to eliminate the transport and delivery of chemical loads to sensitive surface waters. Nutrient management might help safeguard ground water sources and reduce nutrient loadings in surface water while meeting the crop's nutrient requirement [87]. Nutrient management involves the introduction of prescriptive fertilization plans that consider factors such as soils, crop, reasonable yield and weather to provide the perfect quantity of nutrient in the proper time for optimum uptake and utilization through the crop. Artificial drainage is often belittled because the responsible for surface water quality problems.

This critique is really because without contemplation on documented drainage water characteristics, as soil with drainage enhancements will be in close proximity to eco-sensitive waters [88]. Bonaiti and Borin [89] challenged weather controlled drainage and sub-irrigation method would reduce the nutrient losses from agricultural fields. They figured controlled drainage together with sub-irrigation can be utilized at farm scale with the advantage of water conservation and reduce in pollutant loads from agricultural farms. Peng et al. [55] investigated the effect controlled irrigation and drainage on nitrogen leaching losses from paddy fields by evaluating while using traditional flooded irrigation system. They suggested that, using controlled irrigation and drainage could be the most practical method water management and pollutant control of reducing nutrient losses from paddy fields. However, Xiao et al. [90] shown experimentally that, continuous flooding irrigation (FI) happens to be an ideal method of reducing nitrogen concentration and total phosphorus from paddy field's surface water. Essentially, controlled drainage is achieved with structures that permit drainage of just the surplus water that may damage crops or limit farm equipment traffic-ability. One way possible to optimize water use within agriculture is a mix of controlled drainage and sub-irrigation for continuous charge of water table [91 and 92], with the aim of effectively controlling excess drainage, applying a cost-effective irrigation system, saving water, and ameliorating water quality.

To be able to reduce agricultural non-point source pollution and improve water use efficiency, it's essential to investigate the concentration of nutrient loads inside a flooded paddy field under different leakage rates [64]. Use of drainage control cuts down on the frequency of irrigation to decrease demand pressures on water sources by raising water table, and lowers the concentration of chemical fertilizers within the drainage funnel, as well as improves using rain water sources by managing the drainage time after and during the rains [7, 10, 79 and 93]. Therefore, controlled drainage can effectively ease the paddy chemical compounds pollution within the surrounding water, which could play a huge role to manage agricultural non-point source pollution. It cannot only decrease the non-point source pollution of solutes, but additionally not effect rice yield [94].

4 RECYCLING IRRIGATION (RI)

There's considerable worldwide worry about the degeneration in water quality of public water areas. Probably the most key elements adding for this issue are the great deal of pollutants from non-point source pollutions, especially agricultural watersheds. Among several types of agricultural non-point sources, paddy field makes up about a sizable part of agricultural land in certain East Parts of Asia, and in addition they appear in other locations such as North and South America, Africa, Australia, etc. [95]. Many methods for reducing the quantity of pollutants are known as for, including improvement of soil property or fertilizer application [96 and 97], improve paddy drainage [64 and 90], conservation tillage [98], and pollutants removal in wetlands or riparian forest [99]. Accessibility to top quality irrigation water is threatened in lots of places because the introduction of new water supplies doesn't keep pace using the growing water needs of industries and municipalities. Thus, the requirement for land consolidation, improvement of paddy drainage and conservation water quality has brought to the making of separate irrigation and drainage canals rather from the traditional combination canals [100].

Recycling irrigation is a technique of paddy field irrigation that has received much attention, as it might not only save money on irrigation water but additionally reduce pollutants from agricultural watersheds [101, 102 and 103]. Water reuse is within prevalent use as a technique of supplementing the paddy water supply, therefore, there's have to clarify its effects around the paddy system water balance [100]. Kaneki et al. [103], reported that, the pollutant load outflows of nitrogen, phosphorus, and COD from the paddy field using circular irrigation system were reduced by 6.8, 1.1, and 24 kg/ha^{-1} during one irrigation period. Actually, circular irrigation water once drained in the paddy fields is irrigated again around the paddy field within the same watershed. However, this irrigation product is not readily recognized by farm owners where causes of abundant water that is clean can be found, and the quality of the drained water utilized for circulation irrigation is commonly worse compared to other available water sources [104].

Based on a lot of reports on pollutant load in paddy fields, some paddies are pollutant sinks whereas others are pollutant sources [105 and 106]. Zulu et al. [100], evaluated the effects of reuse water on paddy irrigation system, water balance and it is associated grain-land ecosystem. They figured, recycling irrigation wasn't only help meet irrigation water needs, but additionally provided purification of agricultural drainage water. The pollutant sink signifies that the levels of pollutant load output are less than individuals of inflow (irrigation loads). Takeda et al. [104], investigated the potential of reducing non-point source pollution from paddy field using recycling irrigation. They established that, recycling irrigation have desirable purpose of chemical load removal, using the deposition of nutrients were more efficient compared to flushing within the drainage system. Thus, recycling irrigation can lead for that decrease in non-point source pollutions.

Probably the most key elements in pollutant purification of paddy field are hydraulic retention time. Several studies reported the retention amount of time in some artificial wetlands of 4-7 days that is relatively good purification [107 and 108]. Feng et al. (2004), reported a retention duration of 5-9 days during normal period. However retention time mostly depend the quantity of irrigation applied on the paddy fields, a lot of irrigation may lower the retention duration of paddy especially during puddling period. Feng et al. [109], reported retention duration of 4-5 days during puddling paddy field. Takeda et al. [110] reported retention duration of 4 days for total phosphorus and seven days for total nitrogen loads. When it comes to mechanism of pollutant sink in paddy field, a highly effective reason is most likely retention water within the paddy field during irrigation period that relates to purification mechanism in natural and artificial wetland [111].

The decrease in pollutants for instance nitrogen (N), phosphorus (P), organic matter (OM), and suspended solids (SS) discharged from non-point sources is a vital facet of improving water quality of downstream water areas [112 and 113]. Paddy fields, which produce rice as staple food in lots of countries, mainly in the Asian monsoon region, and utilize considerable amounts water throughout the rice growing season really are a major non-point supply of pollution.

Feng et al. [109], studied the behavior of solute transport in paddy field outfitted with recycling irrigation system. They found net output lots of total nitrogen (T-N) and total phosphorus (T-P) as 3.98 and 37 kg/ha correspondingly which signifies the paddy field performed purification function. The result demonstrated the paddy field outfitted with recycling irrigation had the opportunity to remove nitrogen and phosphorus nutrients. Hama et al. [114] assessed the impacts of nutrient mass balance (N) in paddy field under recycling irrigation system. They figured, the fertilizer use of nitrogen could be reduced by its return through recycling irrigation system.

Reclaiming water from irrigation is definitely an alternative option that needs to be examined to meet up with water demands under conditions of growing water deficits. Thus, the supply water can be a pre-condition for sustainable land use within given area [115]. Based on Hama et al. [114], recycling irrigation can help to eliminate the pollutant loads both, because less water leaves in the district and since a few of the pollutants within the drainage water is going to be returned towards the paddy field. Furthermore, paddy fields have a tendency to use great deal of irrigation water and discharge a lot of water, usually greater than 1000 mm, are among non-point source [116, 117 and 118]. Phosphorus is usually a nutrient that whenever contained in high concentrations causes water quality problems in lots of marine systems [118]. Takeda et al. [119], investigated the impact of iron compounds on phosphorus purification inside a paddy field using recycling irrigation. They discovered that iron compounds within the river were sufficient for precipitation on phosphorus. However, the study of watershed was regarded as a considerable iron source, getting 307 and 206 kg/ha of annual outflow loads.

Numerous management practices were carried out for reducing nutrient loads from paddy fields. Field scale practices include reducing quantity of chemical fertilizer utilized by applying slow-release fertilizer [120]. Takeda and Fukushima [60], investigated lengthy term alterations in chemical load outflows from paddy field under recycling irrigation system. The annual net outflows of T-N, and T-P during irrigation and non-irrigation periods were ranged from 13.6 - 75.3 kg/ha/year, -3.55 - 2.21 kg/ha/year correspondingly. They indicated that, the study watershed permitted sufficient retention for pollutant purification for phosphorus content and partly for nitrogen content. Additionally, using recycling irrigation, more water is retained from paddy fields, reducing amount of runoff transporting potential pollutants. The potency of this method is directly proportional to the quantity of water that's reused [103] and also to the intensity [121]. Hama et al. [122] reported the phosphorus effluent load reduction from paddy field by utilizing recycling irrigation system. Their results recommended that, re-utilization of drained water from paddy fields is an efficient method for reducing effluent phosphorus loads.

5 CONCLUSION

Farmers always use an excessive amount of fertilizers to obtain good yield. However, plants will not take all the nutrients applied as some of them percolates below root zone which causes groundwater contamination while the remaining may lost through runoff which eventually causes eutrophication of rivers and lakes. Thus, it is very necessary to find an effective way of controlling the fate and transport of nutrients. Therefore, we evaluated three different methods of controlling the fate and transport of agrochemicals from agricultural fields (water saving irrigation, drainage control and recycling irrigation system). Based on the these three methods, water-saving irrigation is the best option to reduce nutrient losses from agricultural fields as it may not only save water, but also reduces the fate and transport of chemicals from different agricultural fields particularly from paddy fields. We recommend that, future work should carry out in order to assess the suitability of using other useful techniques of reducing N losses from agricultural fields.

6 ACKNOWLEDGMENT

The authors wish to thank the Ministry of Sciences, Technology and Innovation (MOSTI) and University Putra Malaysia (UPM) for sponsoring this research. This research is funded by the Ministry of Sciences, Technology and Innovation (MOSTI) under e-science grant number escience5450774.

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