Review on Pesticide Drainage from Agriculture Practices

***Ajay Kaushik*[1], *Siby John*[2]**

PG Scholar[1], *Professor*[2]

Department of Civil Engineering

PEC University of Technology

Corresponding Author's Email: *ajay.kaushik24@gmail.com*[1]

Abstract

Use of pesticides provides an increase in economy of nation but at the same time it adversely affecting the environment. Pesticide residues are present in all compartments of the environment i.e. soil, sediments, water, fruits and vegetables. More persistent and less biodegradable pesticides (like organochlorines) cause serious health hazards due to its rapid solubility and bioaccumulation in non-targeted organisms. Pesticide drainage from agriculture fields is the major cause of water pollution especially from rice fields as it requires more irrigation which results into high drainage of pesticides with excess water from rice fields. The present study provides a review of surface runoff of pesticides from agriculture field and the factors affecting the surface runoff. It also include the data collection from different papers of surface water contamination of pesticide due to runoff. Data limitation is still a problem to make clear picture of surface water contamination by pesticides. Proper monitoring, assessment and reporting should be implemented to reduce the pesticide exposure.

Keywords: *pesticides, drainage, rice fields, toxicity, half life*

Page 1-15 © MANTECH PUBLICATIONS 2017. All Rights Reserved

INTRODUCTION

To increase crop protection and yield the usage of pesticides has increased a lot in the agricultural fields around the world [Popp et al.,2013]. India is the largest producer of pesticides in Asia and ranks 12th worldwide for the application of pesticides [Bhardwaj et al.,2014].Pesticide pollution from agriculture fields is an issue of concern as its presence in water adversely effects human health and aquatic life. Pesticide usagefound to be linked with cancer cases in many studies. High cancer cases among the rural agriculture community of Punjab in North India were reported [Thakur et al., 2008]. A positiveco-relation has been developed between brain tumours patient and orchards farmers of Kashmir, India [Rashid et al., 2010]. Pesticides are adversely affecting aquatic life too as these organism may dyeing or becoming more susceptible to disease [Sarwar,2016]. Drainage from agriculture fields results in an abrupt increase in the pesticide pollution load into water bodies. Pesticide residue has been distributed globally in water bodies like rivers, Lakes, ground water and small streams [Bhat,2014; Sangchan et al, 2013; Xin , 2012; Marino et al 205]. Pesticide transport through drainage from agriculture fields follow two paths i) runoff ii) leaching. Runoff include surface runoff and sub-surface runoff [Pilgrim et al.,1778].Water is essential commodity of our earth thus it is essential to assess the transport mechanism of pesticide from agriculture fields.

Thus the main purpose of this paper is to provide literature review on pesticide drainage from agriculture fields and factor affecting the pesticide drainage.

2 PESTICIDES FROM AGRICULTURE DRAINAGE

Pesticides applied to target crops, generally get volatilized, degrade and transport through drainage from surface of soil. Other mode of pesticide residue reach to surface water is careless disposal of pesticide containers and equipment washing [Pasiani et al., 2012].

Pesticide which are more persistent due to less degradation capacity are more readily available for transportation and may reach to water [Wagenet 1987] About 60% of pesticides detected in surface water are lost from the field due to surface run-off and drainage [] Fig 1 shows the different path ways of applied pesticides.

 © MANTECH PUBLICATIONS 2017. All Rights Reserved

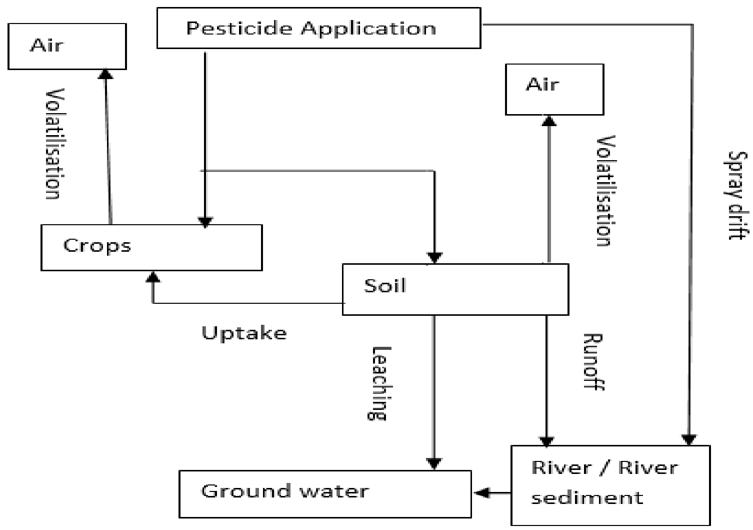

Fig 1: Transport pathways of pesticide applied to crops

2.1 Pesticide transport due to surface runoff:

Runoff of pesticides is the process in which pesticide from the surface of the soil move from soil to surface water. It can be from root zone and sub surface of soil. Runoff occur when infiltration become less then the rain fall rate, after saturation runoff begins[Bucheli et al., 1998]. Erosion is another mechanism of in which sediments of upper soil surface transport with soil nutrients and pesticides that are insoluble or strongly bound to eroding soil. Pesticide highly mobile more likely to leach to groundwater, but unlikely to occur in runoff. Drainage water from irrigation channels at agriculture fields are the critical source of risk of pesticide contamination in surface water[Pong et al., 2010].The other factor may affect the transportation of pesticides including the physical and chemical properties of the pesticides, its formulation, the rate of and type of applications, the crop which it was applied, tillage practices, and topography of the field, weather conditions and amount.

2.2 Factors responsible for pesticide loss from agricultural runoff

Pesticides may be transported in runoff from land to aquatic habitats in true solution, as small, undissolved particles, bound to eroded soil particles and plant debris or dissolved in humate material. A

Page 1-15 © MANTECH PUBLICATIONS 2017. All Rights Reserved

number of factors affect the concentration of pesticides in runoff (i.e., surface drainage water plus suspended soil particles), including the following:

Rainfall characteristics: Rainfall intensity and durations are very important in determining the amount of pesticide lost in runoff. Greatest runoff losses occur when rainfall intensity is high and/or when rainfallamountislarge. Rainfall occur immediately after the application of pesticide spray has been major source of contamination of surface water[Kreuger 1998].High concentration of pesticide were found during rainy seasons[Sangchan et al., 2014].

Pesticide properties. Pesticide formulation and solubility, and the chemical and physical properties that determine a compound's persistence, play a major role in determining how much is lost in runoff. [Wauchope, 1978]reported that pesticides formulated aswet table powders produce the highest long-term losses andthat water-insoluble pesticides generally produce greater long-term losses than soluble compounds.The persistence of a pesticide is related to many factors an dis an integrated response to all the processes act ingon it.The greater the persistence, the longer the pesticide is available to run off forces,and the greater the potential loss by run off. Pesticide persistence is usually measured in terms of half-life,the time required for 50% of the pesticide to disappear. It should be noted that the measured half-life of a pesticide underfield conditions may be less than that under laboratory conditions[Rao et al., 1980]. Because of the greater likelihood of additional dissipative processes (anaerobic degradation, photo degradation, volatilization) under field conditions.The property of pesticide makes them toxic to other non-targeted organism bird, fish, animals and human beings [Crook et al, 1987].

Toxicity bioassay is the degree to which it damage an organism. It include the all organism like animal, bacteria, fungi or plants. These terms are generally represented as LD50 and LC50. The LD50 is the lethal dose in which the amount that must be in or on body that type of animal to kill half of the affected population within a given amount of time. LC50 is the lethal concentration of a material to kill one-half of the animals tested in a specific amount of time.

Page 1-15 © MANTECH PUBLICATIONS 2017. All Rights Reserved

Table 1 Shows the toxicity potential of some insecticide on fish

Insecticide	Relative run-off potential	Relative leaching potential	Half life in days	Relative toxicity to fish[1]
Hydrdamethinon (Amdro®)	Large	small	10	High
Diazinon	Medium	large	30	High
Chlorpurifos (Durisban®)	Large	small	30	very high
Malathion	Small	small	1	very high
Acephate (Orthene®)	Small	small	3	very low
Carbaryl (Sevin®)	medium	small	10	Medium
Dimehoate (Cygon®)	small	medium	7	Medium
Trichlorfon (Dylox®)	small	large	27	High
Dicofol (Kethane®)	large	small	60	High
Propargite (Omite®)	large	small	56	High

Source: EPA, 1992

1Fish Toxicity based on catfish and bluegill. LC50 categories are rated as follows: very low = more than 100 mg/L, low = 10 to 100 mg/L, medium = 1 to 10 mg/L, high = 0.1 to 1 mg/L, very high = less than 0.1 mg/L. ®commercial name.

Rate of application: It is generally agreed that the rate of pesticide application and the amount of pesticide loss in runoff are positively correlated, but the relationship is not necessarily linear [Rao et al., 1980]. The effect of rate of application on amount transported in runoff becomes less effective with the passage of time.

Mode of application: Higher runoff losses occur for surface-applied pesticides than for

Page 1-15 © MANTECH PUBLICATIONS 2017. All Rights Reserved

soil-incorporated pesticides. For water soluble pesticides, losses are usually greater for foliar-applied compounds than for soil-applied.[Wauchope, 1978].

Soil texture and topography: Higher pesticide losses in runoff usually occur from fine-textured soils than from coarse-textured soils, and from soils with greater slopes. Coarse-textured soils usually have higher infiltration rates and lower erosion and runoff volume than do fine-textured soils. Generally, the steeper the slope the greater are the runoff volume and erosion, and the greater is the amount of pesticide lost in runoff [Wischmeier et al., 1978].

Distance of transport: The greater the transport distance, especially across untreated land and vegetation or in major streams, the lower is the concentration in water due to sorption by untreated surfaces, sedimentation of particulate matter and dilution.

2.2 Pesticides detection in surface water

Pesticideconcentrations were found to be high in surface water during monsoon period [Mohammad et al., 2014]. Pesticide contamination of surface water was more as compare to ground water due to runoff during irrigation (Bhat et al., 2014). When water is more than the infiltration capacity then runoff occur, decrease in infiltration leads to the nearby surface water bodies (Bhat et al., 2014). There are many reports on surface water contamination by pesticides which are shown in Table 2.

Table 2 Shows the pesticides residue in surface water

River/tributaries	Pesticides detected	Pesticides level, ng/l	References
Betwa	α-HCH β-HCH γ-HCH Aldrin	BDL- 245 BDL- 329 BDL- 207 BDL- 147	Bhat et al., 2014

Page 1-15 © MANTECH PUBLICATIONS 2017. All Rights Reserved

	Heptachlor Endosulphansulfate	BDL- 118 BDL- 78	
Deomoni	Chlorpyrifos Dicofol Ethion	91-200 180-710 92-375	Swati et al., 2015
Ganga	∑HCH ∑DDT Endosulfan Heptachlor	0.1–17.6 BDL –12.3 BDL –85.4 BDL –11.8	Samanta et al., 2014
Ghaggar	∑HCH ∑DDT	21.13-244.16 238.59-1005.43	Kaushik et al., 2010
Hindon	α-HCH β-HCH γ-HCH Endosulfan Methoxychlor	10000-10500 8500-22700 8100-23000 9200-23500 8800-24900	Ali et al., 2008
Kabini	Heptachlor α-HCH β-HCH 4 ,4'-DDE	BDL-0.755 BDL- 2.298 BDL- 4.970 BDL- 0.410	Rajanna et al., 2014

Page 1-15 © MANTECH PUBLICATIONS 2017. All Rights Reserved

Kaveri	∑HCH ∑DDT	3.2-18.2 0.75-4.17	Rajendran et al., 2006
Lendi	Chlorpyrifos Endosulfan	BDL-100 BDL- 50	Waghmare et al., 2016
Sharda	Dieldrin *α*-HCH *p ,p*'-DDT	BDL- 209 195-277.2 126.9-236.5	Maurya et al., 2013
Yamuna	∑HCH ∑DDT	12.76–593.49 66.17–722.94	Kaushik et al., 2008
Betwa river, Bhopal	α-HCH β-HCH ϒ-HCH Aldrine Endosulfansulphate	BDL-0.128 BDL-0.215 BDL-0.108 BDL-0.083 BDL-0.032	Bhat and Padmaja, 2014
Bijapur	Endosulfan 4-bromro-2-chlorphenol Chloripyrifos	BDL-0.004 BDL-0.009 BDL-0.004	Pujeri et al., 2010

2.3 Pesticide drainage from rice fields:

The application of pesticides in rice fields is high and it effect the rice sample. Moreover it needs high amount of water use for irrigation that makes it more susceptible to runoff. Thus the pesticides from rice field effects rice samples as well as surface water quality through runoff. Pesticide residues in runoff from rice fields has been reported in many studies shown in Table 3.

Page 1-15 © MANTECH PUBLICATIONS 2017. All Rights Reserved

Table 3 Pesticide detected in paddy fields

Region/country	Pesticides detected	Level of pesticides	Reference
Zhejiang Province, China	Carbosulfan Carbofuran 3- hydroxyl carbofuran	BDL- 0.014 mg/l BDL-0.025 mg/l BDL- 0.035 mg/l	Zhang et al. 2015
Amol township, Iran	Diazinon	BDL- 1.1391 ppm	Arjmandi et al. 2010
Savar and Dhamar upzilas, Bangladesh	Carbosulfan Carbaryl Malathion Diazinon	BDL- 198.7 µg/l BDL- 18.1 µg/l BDL- 105.2 µg/l BDL- 0.9 µg/l	Chowdhary et al. 2012
Ghior and Manikganj Sadar upazilas, Bangladesh	Chlorpyrifos Cypermethrin Diazinon	BDL- 0.020 µg/l BDL- 0.0695 µg/l BDL- 0.0012 µg/l	Bhattacharjee et al. 2012
Kurume city, Fukuoka prefecture, Japan	Isoprothiolane Pretilachlor Buprofezin	0.13- 0.40 µg/l 0.84- 8.96 µg/l 0.06- 0.15 µg/l	Phong et al. 2010

In some cases it exceeded above the MRL. In Indian scenario of rice contamination is shown in Table 4. 152 rice samples out of 1076 samples were found be contaminated with pesticide residues and 6.3 % has been exceeded MRL [NDRIK, 2015] Most commonly detected compounds were chlorpyrifos, ethion, acephate and imidacloprid.

Page 1-15 © MANTECH PUBLICATIONS 2017. All Rights Reserved

Table 4 Rice contamination in different states of India

Centers	Sample Analysed	Samples with detected residues	Samples above FSSAI MRL
AAU, Anand	74	1	0
BCKV, Kalyani	66	11	9
IIHR, Bangalore	66	11	9
IITR, Lucknow	72	1	0
IPFT, Gurgaon	72	8	8
KAU, Vellayani	72	19	12
MPKV, Rahuri	56	0	0
NIPHM, Hyderabad	73	51	7
NPQS, Delhi	70	0	0
PAU, Ludhiana	192	1	1
PJTSAU, Hyderabad	73	22	9
RAU, Jaipur	60	0	0
RPQS, Mumbai	58	26	12
TNAU, Coimbatore	72	1	1
Grand Total	1076	152 (14.1 %)	68 (6.3 %)

CONCLUSION

Pesticides spray is an easy way to control insects at significant cost but it increases the toxicity level in the environment. Most of the studies focused on OCPs as these compounds are highly persistent and do not degrade easily in the environment. High concentration of pesticide residue were found in surface water adjoining agricultural field. Some of pesticide found to be more

Page 1-15 © MANTECH PUBLICATIONS 2017. All Rights Reserved

than MRL. Those pesticides which are banned by government, their residues still persist in the environment may be in past high amount of usage leave the amount in present. To reduce pesticide drainage from agriculture fields more field based management practices should be implemented. Some policies should be devised by the government supporting the use of eco-friendly pest control technique which leads to less pesticide consumption among farmers.

REFERENCES

1) Popp J., Peto K. and Nagy J., 2013. Pesticide productivity and food security: A Review. Agron. Sustain. Dev, Vol 33, pp 243-255.

2) Bhat D. and Padmaja P., 2014. Assessment of organic pesticides in ground water and surface water in Bhopal India. IOSR Journal of Environment Science, Toxicology and Food technology. Vol. 8, pp 51-52.

3) Xing Z., Chow L., Cook A., Benoy G., Ree H., Ernst B., Meng F, Li S., Zha T, Murphy C., Batchelor S., Hewitt L.M., 2012. Pesticide application and detection in variable Agricultural Intensity watersheds and their river system in the maritime region of Canada.Arch Environ Contam Toxicol. Vol 63, pp 471-483.

4) Marino D and Ronco A., 2005. Cypermethrin and chlorpyrifos concentration levels in surface water bodies of the Pampa Ondulada, Argentina. Environmental Contamination and Toxicology. Vol 75, pp 820-826.

5) Sangchan W., Bannwarth M, Ingwersen J., Hugenschmidt C., Schwadorf K., Thavornyutikarn P., Pansombat K. and Streck T.,2014. Monitoring and risk assessment of pesticides in a tropical river of an agriculture watershed in northern Thailand. Environ Monit Assess. Vol 186, pp1083-1099.

6) Pilgrim D.H., Huff D.D., and Steele T.D., 1978. A field evaluation of subsurface and surface runoff II Runoff processes. Journal of Hydrology. Vol. 38, pp 319-341.

Page 1-15 © MANTECH PUBLICATIONS 2017. All Rights Reserved

7) Cook J.L., baumann P., Jackman J.A. and Stevenson D., Pesticides characteristics that affect water quality. Report, http://insects.tamu.edu/extension/bulletins/water/water_01.html.

8) Bucheli T.D., Muller S.R., Heberle S. and Schwarzenbach, 1998. Occurrence and behaviour of pesticide in rain water, roof runoff and artificial stromwater infiltration. Environmental Science and Technology. Vol 32, 3457-3464.

9) Farmers Chemcal Handbook 95, Meeister Publication Co. Willoughby, 1995

10) R.E. Gosselin, H.C. Hodge, R.P. Smith and M.N. Glean, “Chemical Toxicity of Chemical Products,” The wilkins & Wilkins Co., Batimore, 1997

11) Sarwar M., 2016. Insecticide risk exposure threat to aquatic life in surface water bodies and its remedying. International Journal for Research in Applied chemistry Vol 1, pp 1-9.

12) Bhardwaj, T. and Sharma, J. P., 2013. Impact of pesticides application in agricultural industries: An Indian Scenario, International Journal of Agricultural and Food Science Technology, Volume 4, pp 817-822.

13) Annual progress report, 2014-2015. Monitoring of pesticide residue at national level. Ministry of Agriculture & Farmers Welfare Krishi Bhawan, New Delhi.

14) United States Environmental Protection Agency. 1990. The quality of our nation's water: A summary of the 1988 national water quality inventory. EPA 440/4-90-005.

15) Wagenet R.J. 1987. Process influence pesticide loss with water under conservation tillage. In : Logan T.J., Davinson J.M., Baker J.L., Overcash M.R., effect of conservation tillage on groundwater water quality: nitrate and pesticides. Lewis, Chelsea pp 189-204.

16) Phong T., Yoshino K., Hiramatsu K., harada M., Inoue T., 2010. Pesticide discharge and water management in a paddy catchment in Japan. Paddy water Environment. Vol. 8, pp 361-369.

17) Kreuger J. 1998. Pesticide in stream water with in an agriculture catchment in southern Sweden, 1990-1996. Sci Total Environment Vol. 216, pp 227-251.

18) Sangchan W., bannwarth M., Ingwersen J., Hugenschmidt C., Schwdorf K., Thavornutikarn P., Pansombat K. and Streck T. 2014. Monitoring and risk assessment of pesticide in a tropical river of an agriculture water shed in northern Thailand. Enviornment Monitoring assessment, Vol.186, pp 1083-1099.

19) Pasiani, J.O., Torres, P., Silva, J.R., Diniz, B.Z., Cadlas, E.D. Knowledge, attitudes, practices and biomonitoring of farmers and residents Exposed to pesticides in Brazil. International Journal Environmental Research Public Health Vol 9,pp 3051-3068.

20) Bhat, D., and Padmaja, P., 2014. Assessment of Organic Pesticides in Ground and Surface Water in Bhopal, India. IOSR Journal of Environmental Science, Toxicology and Food Technology Vol. 8, pp 51-52.

21) Singh, S., Bhutia, D., Sarkar, S., Kishore B. R., Pal, J., Bhattacharjee, S., Bahadur, M., 2015. Analyses of pesticide residues in water, sediment and fish tissue from river Demoni flowing through the tea gardens of Terai Region of West Bengal, India. International Journal of Fisheries and Aquatic Studies. Vol 3, pp 17-23.

22) Samanta S., 2013. Metal and pesticide pollution scenario in Ganga River system. Aquatic Ecosystem Health & Management, Vol 16, pp 454-464.

23) Kaushik, A., Sharma, H. R., Jain S., Dawra, J., Kaushik, C. P., 2010. Pesticide pollution of River Ghaggar in Haryana, India. Environ Monit Assess Vol 160, pp 61–69.

 © MANTECH PUBLICATIONS 2017. All Rights Reserved

24) Ali, I., Singh, P., Rawat M.S.M., Badoni, A., 2008. Analysis of organochlorine pesticides in the hindon river water, India. Journal of environmental protection science, Vol. 2, pp 47-53.

25) Rajanna, A. H. and Belagali, S. L., 2014. Pesticides Persistence in Soil and Kabini River Water at Nanjangud Region. International Journal of Innovative Research in Science, Engineering and Technology, Vol. 3,pp 10765-10773

26) Rajendran, R. B. and subramanian, A. 1997. Pesticide Residues in Water From River Kaveri, South India. Chemistry and Ecology, Vol 13, pp 223-236

27) Waghmare, B. D. & Kulkarni, A. N., 2015. Analysis of Pesticides in Lendi River, District Nanded, (M.S.), India. Journal of Environmental Science, Computer Science and Engineering & Technology, Vol. 5, pp 94-98

28) Maurya A. K. and Kumar, A., 2013. Organochlorine Pesticides in the Surface Waters from Sharda River Region, Uttar Pradesh-India. The SIJ Transactions on Advances in Space Research & Earth Exploration (ASREE), Vol. 1, pp 1-7

29) Mutiyar, P.K. and Mittal, A.K., 2013. Status of organochlorine pesticides in Ganga river basin: anthropogenic or glacial? Drinking Water Engineering and Science, 6(2), pp.69-72.

30) Wauchope R.D. 1978. The pesticide content of surface water draining from agricultural fields - A review. J. Environ. Qua. Vol 7, pp 459-472

31) Rao, P. S. C. and Davisdon J. M. 1980. Estimation of pesticide retention and transformation parameters required in nonpoint source pollution models. In M. Overcash and J. Davidson, eds., Environ- mental Impact of Nonpoint Source Pollution. Ann Arbor Science Publishers, Ann Arbor, Ml, pp 23-68

32) Merkle M.G. and Bovey R. W., 1974. Movement of pesticides in

Page 1-15 © MANTECH PUBLICATIONS 2017. All Rights Reserved

surface water. In W. Guenzi, ed., Pesticides in Soil and Water. Soil Sci. Soc., Am., Madison, WI, pp 99-106.

33) Wischmeier W.H. and Smith, D. D. 1978. Predicting rainfall erosion losses - A guide to conserva- tion planning. USDA Agric. Handbook 537.

34) Arjmandi R., Tavakol M., Shayeghi M., 2010. Determination of organophosphorus insecticide residues in the rice paddies. Int. J. Environ. Sci. Tech., Vol 7, pp 175-182

35) Bhattacharjee S., Fakhruddin A. N. M., Chowdhury M. A. Z., Rahman M. A., Alam M. K. 2012. Monitoring of Selected Pesticides Residue Levels in Water Samples of Paddy Fields and Removal of Cypermethrin and Chlorpyrifos Residues from Water Using Rice. Bran. Bull. Environ. Contam. Toxicol. Vol 89, pp 348–353

36) Chowdhury M. A. Z., Banik S., Uddin B., Moniruzzaman M., Karim N., Gan S.H., 2012. Organophosphorus and carbamate pesticide residues detected in water samples collected from paddy and vegetable fields of the Savar and Dhamrai Upazilas Int. J. Environ. Res. Public Health, Vol 9, pp 3318-3329

37) Zhang Chang P., He Hong M., Yu Jian Z., Hu Xiu Q., Zhu Ya H., and Wang Qiang (2015) Residues of carbosulfan and its metabolites carbofuran and 3-hydroxy carbofuran in rice field ecosystem in China, J. Env. Sci. Health, Part B Vol. 0, pp 1–7

38) Phong, T.K., Yoshino, K., Hiramatsu, K., Harada, M. and Inoue, T., 2010. Pesticide discharge and water management in a paddy catchment in Japan. Paddy and Water Environment, Vol 8, pp 361-369.

39) https://pubchem.ncbi.nlm.nih.gov/compound

 Page 1-15 © MANTECH PUBLICATIONS 2017. All Rights Reserved