



**Cairo University**

**STUDY THE EFFICIENCY OF DRIP IRRIGATION  
SYSTEM USING LASER BEAM – IN VITRO**

By

**MOHAMMED MOUSTAFA MAHMOUD**

B.Sc. Agricultural Engineering, Faculty of Agric., Al-Azhar University, 2009

**Submitted for the Degree of  
Master**

**IN  
Laser Science**

**Department of Laser Application in Metrology, Photochemistry and  
Agriculture (LAMPA)**

**Laser Application in Biotechnology and Agriculture  
Agricultural Engineering**

**National Institute of Laser Enhanced Sciences  
Cairo University  
Giza, ARE**

**2020**

## ABSTRACT

The present study was executed in the Laboratory of Laser Applications in Agricultural Engineering at the National Institute of Laser Enhanced Science (NILES) at Cairo University to obtain the peak of optical properties at transmission and absorption intensities of irrigation water samples which carried out at the National Irrigation Laboratory of Agricultural Engineering Research Institute (AEnRI), ARC, Dokki, Giza. The main objectives of the present work are to create a selection of suitable wavelength to study the optical properties of suspended solids in filters and determination of concentration suspended solids in the filtration media.

In the drip irrigation system, the small openings can be easily clogged by suspended solids according to the level of TSS and plugging is caused fall into three categories (<50, 50-100, >100) (Slight, Moderate, Severe) respectively.

Light was measured via remote sensing reflectance ( $R_{rs}$ ) spectra deduced from radiance and irradiance measurements that were performed using an Ocean Optics USB650 to detect suitable wavelengths from visible and invisible light (ultraviolet, visible and infrared wavelengths) to measure the peak of optical properties at reflection, transmission and absorption.

It was found that using a media filter of Local basalt media increased TSS in a water sample and created filter pressure differential results. It increased from 0.2 bar to 0.6 bar and also increased absorption (0.189 to 0.447a.u.). Reflection and transmission decreased (79.285 to 49.645a.u.), (78.288 to 44.711a.u.).

When using a media filter of Al-Abaster Misr Bank media. This increased TSS in the water sample and created filter pressure differential results that increased from 0.2 bar to 0.6 bar and increased absorption (0.205 to 0.520 a.u.) while decreasing reflection and transmission (76.047 to 36.672a.u.), (80.759 to 36.278a.u.).

A media filter of Ward El-Nile Zaffaran media increased TSS in the water sample and created filter pressure differential results that increased from 0.2 bar to 0.6 bar while increasing absorption (0.224 to 0.815a.u.) and decreasing reflection and transmission (67.37 to 27.37a.u.), (69.65 to 26.64a.u.).

Meanwhile, an evaluation of the dripper's efficiency according to the use of appropriate filtration media for the first filter yielded the following

results: Local basalt media (0.2, 0.4 and 0.6 bar) showed emission uniformity of EU% 94.73, 89.553 and 79.649% (excellent, good and fair results, respectively). The second filter of Al-Abaster Misr Bank media (0.2, 0.4 and 0.6 bar) showed EU% 95.578, 87.561 and 68.562% (excellent, good and poor results, respectively). The third filter of Ward El-Nile Zaffaran media (0.2, 0.4 and 0.6 bar) showed EU% 95.836, 89.664 and 79.566% (excellent, good and fair results, respectively).

For determining the most accurate filtering media type with the highest efficiency for filtration, the values were 79.3% and 76.9%, respectively, for Local basalt media and Al-Abaster Misr Bank media. When using the filter of Ward El-Nile Zaffaran media, however, the removal efficiency was low at 40.97%.

These results show that there are two kinds of filtering media, Local basalt media and Al-Abaster Misr Bank media, that are acceptable and another kind, Ward El-Nile Zaffaran media that is unacceptable. It is possible to distinguish and evaluate the optical properties for Local basalt media and Al-Abaster Misr Bank media. Laser properties measurements were performed using a He-Ne laser at 632.8 nm.

**KEYWORDS:-**

Filter - Drip irrigation system - Total Suspended Soiled (TSS) - Optical Properties - Ocean Optics - He-Ne Laser.

# CONTENTS

	<b>Subject</b>	<b>Page No.</b>
	<b>List of Tables</b>	<b>IV</b>
	<b>List of Figures</b>	<b>VI</b>
<b>1</b>	<b>INTRODUCTION</b> .....	<b>1</b>
<b>2</b>	<b>REVIEW OF LITERATURE</b> .....	<b>3</b>
2.1	Drip Irrigation systems.....	3
2.1.1	Definitions.....	4
2.1.2	Trickle irrigation system components.....	4
2.1.3	The advantages and disadvantages of trickle irrigation system.....	5
2.2	Water quality.....	9
2.2.1	Fresh Water .....	9
2.2.2	Water quality and drip irrigation system.....	12
2.2.3	Physical properties of water on drip irrigation system.....	13
2.3	Media filters selection.....	14
2.3.1	Filtration.....	15
2.3.2	Selection of filter type.....	15
2.3.3	Media Characteristics.....	16
2.3.4	Sand media filters.....	17
2.3.5	Effect of filtration media on chemical properties of irrigation water.....	18
2.3.6	Mechanical analyses of filtration media.....	19
2.3.6.1	Mechanical analyses.....	19
2.3.6.2	Uniformity Coefficient.....	29
2.3.6.3	Effective Particle Size.....	20
2.3.7	Physical properties of filtration media.....	20
2.4	Media filter and its effect on physical properties of irrigation water.....	21
2.5	Remote sensing technology.....	22
2.5.1	Remote sensing technology in precision agriculture (PA).....	22
2.5.2	Relationship between remote sensing and water quality.....	25

2.5.3	Relationship between wavelength (reflectance) and turbidity and total suspended solids.....	30
2.6	Theory of bio-optical model.....	32
2.7	The summary of the literature review.....	36
<b>3</b>	<b>MATERIALS AND METHODS.....</b>	<b>37</b>
3.1	Materials.....	37
3.1.1	A Control Head Unit.....	37
3.1.2	A hydraulic test bench.....	38
3.1.2.1	Hydraulic system description.....	40
3.1.2.2	Water temperature and filtration.....	40
3.1.2.3	Supporting frame.....	41
3.1.2.4	Catch can water from emitters.....	41
3.1.2.5	Measuring devices.....	41
3.1.3	A Light and spectrophotometer.....	42
3.1.4	Laser Setup.....	44
3.1.5	Irrigation system layout.....	45
3.2	Methods.....	46
3.2.1	The test producer.....	46
3.2.2	Filter Media Properties.....	47
3.2.2.1	Chemical analysis.....	47
3.2.2.2	Permeability measurement.....	48
3.2.2.3	Mechanical analysis.....	49
3.2.2.4	Physical analysis.....	51
3.2.2.5	Removal efficiency.....	53
3.3	Methods of calculation.....	53
3.3.1	Performance and evaluation of the selected emitters.....	54
3.3.1.1	Pressure- flow relationships.....	54
3.3.1.2	Emitter manufacture’s coefficient of variations.....	55
3.3.1.3	Emission uniformity (EU).....	55
3.4	Analysis of data.....	56
<b>4</b>	<b>RESULTS AND DISCUSSION.....</b>	<b>57</b>

4.1	Emitter performance.....	57
4.1.1	System evaluation.....	57
4.2	Optical properties (Absorption, Reflection, Transmission coefficient and its spectral optical properties).....	61
4.2.1	Optical properties the first filter using Local basalt media.....	61
4.2.2	Optical properties of water from the second filter: using Al-Abaster Misr Bank media.....	71
4.2.3	Optical properties of water from the third filter: using Ward El-Nile Zaffaran media.....	81
4.3	Filter performance.....	91
4.3.1	Removal efficiency was calculated with the following equation.....	91
4.4	Analysis of data.....	92
4.4.1	Statistical analysis of TSS and wavelength.....	92
4.4.2	Paired-Samples T-test of TSS and wavelength.....	100
4.5	Optical properties: He-Ne laser 632.8nm properties .....	101
4.5.1	Laser properties for three type's media filter at a difference pressure ( $\Delta p$ ) 0.2 bars at wavelength 623.8 He-Ne laser.....	101
4.5.2	Laser properties for three type's media filter at a difference pressure ( $\Delta p$ ) 0.4 bars at wavelength 623.8 He-Ne laser.....	102
4.5.3	Laser properties for three type's media filter at a difference pressure ( $\Delta p$ ) 0.6 bar at wavelength 623.8 He-Ne laser.....	103
4.5.4	Laser properties for three type's media filter at a difference pressure ( $\Delta p$ ) 0.2, 0.4, 0.6 bar at wavelength 623.8 He-Ne laser.....	104
<b>5</b>	<b>SUMMARY AND CONCLUSIONS.....</b>	<b>109</b>
<b>6</b>	<b>REFERENCES.....</b>	<b>118</b>
	<b>ARABIC SUMMARY.....</b>	

<b>Table No.</b>	<b>LIST OF TABLES</b>	<b>Page No.</b>
2.1	Criteria for Plugging Potential of Drip Irrigation System Water Sources...	12
2.2	Values used for the absorption of pure water in UV-A and UV-B wavelengths.....	35
3.1	Specifications of pumping unit.....	37
3.2	Specifications of ocean optics USB 650 made of USA.....	42
3.3	Specification of Media filter types tested in the experiment.....	47
3.4	PH and electrical conductivity (E.C) for types of media.....	48
3.5	Soluble salt percentage of tested media samples.....	48
3.6	CaCO <sub>3</sub> % in the samples at different types.....	49
3.7	The Permeability of gravel material for types of media.....	50
3.8	Mechanical analysis of media properties samples .....	52
3.9	Physical properties of gravel samples.....	53
3.10	Water quality parameters for the SDI (surface drip irrigation) system.....	53
4.1	Performance evaluating of first filter using Local basalt media.....	58
4.2	Performance evaluating of second filter using Al-Abaster Misr Bank media.....	59
4.3	Performance evaluating of third filter using Ward El-Nile Zaffaran media	60
4.4	Optical properties results of first filter using Local basalt media at $\Delta P$ 0.2 bar and TSS 51.8 mg/l.....	62
4.5	Optical properties results of first filter using Local basalt media at $\Delta P$ 0.4 bar and total suspended solids (TSS 115 mg/l).....	65
4.6	Optical properties results of first filter using Local basalt media at $\Delta P$ 0.6 bar and TSS 268.8 mg/l.....	68
4.7	Relationship between of absorption, reflection and Transmission Intensities, difference pressure ( $\Delta P$ ) and total suspended solids (TSS)....	70
4.8	Optical properties of water from the second filter: using Al-Abaster Misr	72

	Bank media at a difference pressure ( $\Delta P$ ) 0.2 bar.....	
4.9	Optical properties of water from the second filter: using Al-Abaster Misr Bank media at a difference pressure ( $\Delta P$ ) 0.4 bar.....	75
4.10	Optical properties of water from the second filter: using Al-Abaster Misr Bank media at a difference pressure ( $\Delta P$ ) 0.6 bar.....	78
4.11	Relationship between of difference pressure ( $\Delta P$ ), absorption, reflection and Transmission Intensities, and total suspended solids (TSS) of water from the second filter using Al-Abaster Misr Bank media.....	80
4.12	Optical properties of water from the third filter: using Ward El-Nile Zaffaran media at a difference pressure ( $\Delta P$ ) 0.2 bar.....	82
4.13	Optical properties of water from the third filter: using Ward El-Nile Zaffaran media at a difference pressure ( $\Delta P$ ) 0.4 bar .....	85
4.14	Optical properties of water from the third filter: using Ward El-Nile Zaffaran media at a difference pressure ( $\Delta P$ ) 0.6 bar.....	88
4.15	Relationship between of difference pressure ( $\Delta P$ ), absorption, reflection and Transmission Intensities, and total suspended solids (TSS) of water from the second filter using Ward El-Nile Zaffaran media.....	90
4.16	Descriptive analysis of TSS with deferent type of media of filter.....	93
4.17	Descriptive analysis of Wavelength with deferent type of media of filter..	94
4.18	Analysis of Variance (ANOVA) for TSS with deferent type of media of filter.....	95
4.19	Analysis of Variance (ANOVA) for wavelength with deferent type of media of filter.....	95
4.20	Descriptive analysis of TSS with pressure difference of filter.....	96
4.21	Descriptive analysis of Wavelength with pressure difference of filter.....	98
4.22	Analysis of Variance (ANOVA) for TSS with pressure difference of filter.....	99
4.23	Analysis of Variance (ANOVA) for wavelength with pressure difference of filter.....	99
4.24	Output of statistical analysis for pressure difference with TSS and wavelength.....	100



<b>Figure No.</b>	<b>LIST OF FIGURES</b>	<b>Page No.</b>
2.1	Basic components of a localized irrigation system.....	5
2.2	Remote sensing technology.....	24
3.1	Photograph of the control head unit.....	38
3.2	Photograph of the media filter.....	38
3.3	Hydraulic test bench components.....	39
3.4	Photograph of the ocean optics USB 650.....	42
3.5	Experimental setup for quality evaluation of water quality.....	44
3.6	Photograph of the laboratory Irrigation system layout .....	46
3.7	Photograph of the laboratory test sieve analyses .....	50
3.8	Photograph of the media samples .....	50
3.9	Photograph of the sieve analyses of particle media .....	50
3.10	Cross section of built-in tubes.....	53
4.1	Relationship between light wavelength, absorption, transmission and reflection intensities at difference pressure 0.2 bar .....	63
4.2	Optical properties of water from first filter using Local basalt media at pressure differential ( $\Delta P$ ) 0.4 bar and TSS 115 mg/l .....	66
4.3	Optical properties of water from first filter using Local basalt media at pressure differential ( $\Delta P$ ) 0.6 bar and TSS 268.8 mg/l .....	69
4.4	Optical properties of water from the second filter: using Al-Abaster Misr Bank media at a difference pressure ( $\Delta P$ ) 0.2 bar.....	73
4.5	Optical properties of water from the second filter: using Al-Abaster Misr Bank media at a difference pressure ( $\Delta P$ ) 0.4 bar.....	76

4.6	Optical properties of water from the second filter: using Al-Abaster Misr Bank media at a difference pressure ( $\Delta P$ ) 0.6 bar.....	79
4.7	Relationship between light wavelength and optical properties for water from the third filter using Ward El-Nile Zaffaran media at a difference pressure ( $\Delta P$ ) 0.2 bar.....	83
4.8	Relationship between light wavelength and optical properties for water from the third filter using Ward El-Nile Zaffaran media at a difference pressure ( $\Delta P$ ) 0.4 bar.....	86
4.9	Relationship between light wavelength and optical properties for water from the third filter using Ward El-Nile Zaffaran media at a difference pressure ( $\Delta P$ ) 0.4 bar.....	89
4.10	Relationship between total suspended solids, absorption and transmission intensities at difference pressure 0.2 bar for three type's media filter.....	101
4.11	Relationship between total suspended solids, absorption and transmission intensities at difference pressure 0.4 bar for three type's media filter.....	102
4.12	Relationship between total suspended solids, absorption and transmission intensities at difference pressure 0.6 bar for three type's media filter.....	103
4.13	Relationship between total suspended solids, absorption and transmission intensities at difference pressure 0.2, 0.4, 0.6 bar for local basalt filter....	105
4.14	Relationship between total suspended solids, absorption and transmission intensities at difference pressure 0.2, 0.4, 0.6 bar for misr bank media filter.....	105
4.15	Relationship between total suspended solids, absorption and transmission intensities at difference pressure 0.2, 0.4, 0.6 bar for zaffaran media filter. ....	106
4.16	Relationship between total suspended solids, absorption and transmission intensities at difference pressure 0.2, 0.4, 0.6 bar for three type's media filter. ....	106
4.17	Relationship between total suspended solids, absorption and transmission intensities at difference pressure 0.2, 0.4, 0.6 bar for local basalt filter....	107

4.18	Relationship between total suspended solids, absorption and transmission intensities at difference pressure 0.2, 0.4, 0.6 bar for misr bank media filter.....	107
4.19	Relationship between total suspended solids, absorption and transmission intensities at difference pressure 0.2, 0.4, 0.6 bar for zaffaran media filter. ....	108
4.20	Relationship between total suspended solids, absorption and transmission intensities at difference pressure 0.2, 0.4, 0.6 bar for three type's media filter. ....	108