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Dialysis Solution Analysis for Peritonitis Infection Prevention by using Optical System Prototype

تحليل محلول الغسيل الكلوي للوقاية من الالتهاب البرتوني باستخدام نموذج النظام
الضوئي

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Degree in Biomedical Engineering

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DEDICATION

This thesis is dedicated to the dear absent present always, my father.

To my mother, who continues to learn, grow and develop and who has been a source of encouragement and inspiration to me throughout my life.

Dedicated the thesis to my parent especially my sister D. Alia for her great care to what improves research and follow-up for each new in the research.

To that person who near even with far distance.

To peritoneal dialysis patients and their family and wish them health and wellness.

To my university source of science and knowledge and to honorable doctors and teacher.

To my friends especially that one who I found her in the stress time and when I need someone to hear me.

To every one support me and give value to the research.

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ABSTRACT

Continuous Ambulatory Peritoneal Dialysis CAPD peritonitis usually occurs due to contamination by bacteria from the skin or the environment of the inserted catheter, peritonitis infection is an important cause of CAPD failure and patients switching to another treatment, it has many signs the predominant one is a cloudy bag, this research used the cloudy bag sign to detect the infection in an early stage.

The aim of this study was to analyze dialysis solution for peritonitis infection prevention by designing a simple prototype to detect the turbid solution by using Scattering Light Theory. This study was applied on 14 patients (male and female) with different ages. Two samples were taken from the patients one was reading at the same time, the second was sub culturing by standard bacterioto simulate the peritonitis infection proportion to the difficulty of finding peritonitis infection samples. 180 known samples were detected by the prototype 90 samples with bacteria and 90 without bacteria to determine the range of normal and abnormal.

The inverse relationship where the greater dispersion of light (increased turbidity) the less resistance value in the examined samples. The classification function was produced and gave result with the normal and infected sample with accuracy equal to (70.9%). The prototype reading was compared with laboratory turbidimeter on National Public Health Laboratory (STAC) and gave satisfied results. Optical system is a simple way for turbidity detection, help old and new patient to detect the peritonitis infection in an early stage.

المستخلص

الالتهاب البرتوني يحدث في العادة بسبب التلوث بالبكتريا الموجودة في الجلد او البيئة المحيطة بالقسطرة وهو من اهم الاسباب التي تودئ الي فشل الغسيل البرتوني و التحويل الي الغسيل الدموي.الالتهاب البرتوني له العديد من الاشارات ،تعكر المحلول المستخدم هي الاشارة غالبية الحدوث لذلك استخدمت هذه الخاصية للكشف المبكر عن الالتهاب.

الهدف الاساسي من هذه الدراسة هو تحليل المحلول للوقاية من الالتهاب وذلك عن طريق تصميم جهاز بسيط للكشف عن المحلول المعكر باستخدام نظرية تشتت الضوء.الدراسة طبقت علي 14 مريض،ذكور واثاث باعمار مختلفة حيث اخذت عينتان من المريض عينة يتم قراءاتها مباشرة واخري يتم تزرير البكتريا بها باستخدام بكتريا قياسية ومن ثم يتم قراءاتها وهذا لنحاكي الالتهاب البرتوني نسبة لصعوبة ايجاد عينات التهاب برتوني. تم فحص 180 عينة 90 منهم من دون بكتريا و90 اخرى ببكتريا لتحديد المدي الطبيعي والغير طبيعي.

العلاقة العكسية مابين تشتت الضوء وقيمة المقاومة حيث انه كلما زاد تشتت الضوء (زيادة التعكر) كلما قلت المقاومة في العينات المفحوصة. تم ايجاد المعادلة التصنيفية وقد اعطت نتائج للعينات السليمة والمصابة بدقة مساوية ل(70.9%).تمت مقارنة قراءات الجهاز مع قراءات جهاز العكورة الموجود بالمعمل القومي للصحة العامة وكانت النتيجة مرضية. النظام الضوئي طريقة بسيطة في الكشف عن العكورة ومساعدة كبار السن والمرضي الجدد في معرفة الالتهاب البرتوني في مراحلها الاولى.

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LIST OF ABBREVIATIONS

GFR	Glomerular Filtration Rate
PD	Peritoneal Dialysis
CAPD	Continuous Ambulatory Peritoneal Dialysis.
CCPD	Continuous Cycling Peritoneal Dialysis
OBD	Optical Bacteria Detector
E.coli	Escherichia Coli
s. aureus	Staphylococcus aureus
CCD	charge coupled Device
SERS	Surface-enhanced Raman spectroscopy.
FTIR	Fourier Transform Infrared
IV	Intravenous
WBC	White Blood Cells
PCR	Polymerase Chain Reaction
RGD	Rayleigh-Gans-Debye
DA	Discriminant Analysis
LDA	Linear Discriminant Analysis
STAC	National Public Health Laboratory
ATCC	American Type Culture Collection
LED	Light Emitting Diode
MC	Micro Controller
LDR	Light Dependent Resistor
LCD	Liquid Crystal Display
OD	Optical Density

LIST OF SYMBOLES

c	Speed
α	Absorption coefficient
τ	The turbidity
e and 10	Exponential decays
c	Concentration (g/ml)
n	The refractive index
N_A	Avogadro's number
λ_0	The wavelength in vacuo
Q	The particle dissipation factor
θ	scattering angle
$P(\theta)$	The ratio of the actual scattered intensity of a particle to the scattered intensity without interference
d	Principal dimension
q_{2n}	The coefficients
n_0	The refractive index of the suspending medium
v	The number concentration of particles
D	Discriminate function
v	The discriminant coefficient or weight for that variable
X	Respondent's score for that variable
a	Constant
i	The number of predictor variables
p	For significant test (< 0.05)

R^2	Variance
df	Degree of freedom
X1	Lower
X2	Upper
X3	Solution

CHAPTER ONE

INTRODUCTION

CHAPTER ONE

INTRODUCTION

1.1 General Overview:

Chronic Kidney Disease (CKD) is a gradual and permanent loss of kidney function[1], Chronic kidney disease can either be defined as kidney damage or a glomerular filtration rate (GFR) of less than 60 ml/min/1.73 m² for a minimum period of three months and diagnosed without knowledge of its cause[2].

There are five stages of chronic kidney disease:

1. GFR $\geq$ 90 Kidney damage with normal or increased kidney function
2. GFR 60–89 Kidney damage with a slight decrease in kidney function
3. GFR 30–59 Average kidney function
4. GFR 15–29 Serious decrease in kidney function
5. GFR < 15 Kidney failure

Causes:

The most common causes of chronic kidney disease is chronic glomerulonephritis (30%) followed by diabetes mellitus (18%), hereditary polycystic kidney disease (13%), chronic pyelonephritis (10%) and nephrosclerosis (9%). As for the remaining 20 percent, the cause cannot be determined[2]

Treatment Option:

There are many type of treatment, determine by the patient's physical condition, emotional condition and family.

1. Hemodialysis.
2. Home Hemodialysis.
3. Peritoneal Dialysis (PD).
4. Kidney Transplantation [3].

The Peritoneal Dialysis:

Peritoneal dialysis removes waste products and excess fluid from the blood through the peritoneum. The peritoneum is a membrane that surrounds all of our organs. This membrane acts like an artificial filter that filters out waste products and excess fluid. In peritoneal dialysis, a catheter is surgically placed in the abdomen and dialysate is instilled into the abdomen and left for a number of hours. After a prescribed amount of time, the dialysate is drained out of the abdomen. It is a slower dialysis method and must be done several times during the day, every day. Sterility is vital during peritoneal dialysis connections [3]. There are two types of home peritoneal dialysis:

1-Continuous Ambulatory Peritoneal Dialysis (CAPD):

It is a manual method of doing exchanges. The patient connects a fill and drain bag to the catheter, performs the exchange and disconnects the tubing from the catheter. Exchanges must be done four to five times per day during waking hours. Precautions must be taken to assure sterile connections to the catheter [3].

2-Continuous Cycling Peritoneal Dialysis (CCPD):

It is a method of doing exchanges with a machine called a cyclor. The patient connects his catheter to the cyclor at midday or

late afternoon, which automatically drains and fills the abdomen once. The patient disconnects himself and is free until bedtime [3].

At bedtime, the patient reconnects himself to the cyclor and the cyclor automatically drains and fills the abdomen four to five more times during the night while the patient sleeps eight to 10 hours. Sterility is vital during the dialysis connections [3].

The Infection in the Peritoneal Dialysis:

The infection is develop in the skin around the catheter or inside the abdominal cavity (called peritonitis).

[1] Catheter Site Infection:

The signs of catheter site infection are:

- Redness, firmness, or tenderness of the skin around the catheter.
- Pus-like drainage from the area [4].

[2] Peritonitis

Peritonitis is the term used to describe an infection of the abdominal cavity. People who use peritoneal dialysis are at risk of peritonitis because bacteria can enter the abdomen through or around the peritoneal dialysis catheter, Signs of peritonitis are:

- Abdominal pain, which may be mild to severe.
- Cloudy used dialysate fluid.
- Fever (temperature greater than 100.4°F or 38°C).
- Nausea or diarrhea.[4]

This research focus on peritoneal dialysis treatment and specifically on infection associated with.

Due to the severity of infection in term of endurance and it may lead to the failure of the peritoneum membrane which could force us to transfer to another treatment.

The research analyzes a number of ways to detect infection in the early stages and by focusing on a proven signs of infection, depending on the properties of light and light interaction with medium where the used light scattering theory and measurement of turbidity.

The detection of the peritonitis infection was done by patients, which require a small amount of fluid that has been drained out in a small transparent container. The patients are looking for a change in transparency of the fluid as this would suggest infection, this method is difficult for old and new patient.

This research proposed a new device for detection the infection depend on the turbidity of the solution, scattering light theory and using micro controller for precise detection to help patient.

1.2 Problem Statement:

In the peritoneal dialysis, patient are trained to detect the infection, the standard method requires the patients to inspect a small amount of fluid that has been drained out in a small transparent container. The patients are looking for a change in transparency of the fluid as this would suggest infection.

- The old method did not give the precise reason (depend on patient) misleading.
- Difficult for patient with visual problem to detect the infection
- New Patient cannot detect the small change in drained fluid

1.3 Proposed Solution:

Design a new device using light scattering theory to differentiate between cloudy and non-cloudy solution.

1.4Objective:

Analysis dialysis infection solution and design a simple device to:

- Detect the smallest change in drained fluid color caused infection.
- Prevent the first peritonitis infection in new patient.
- Assist patient with visual problem.

1.5Scope:

The scope is using light scattering theory to detect and measure the turbidity of the used dialysate which indicate to the peritonitis infection with electronic part consist of microcontroller, detector and display unit.

1.6Methodology:

In this research there are four steps involved to obtain the required objective, the first step is theoretical review, the second is examination step, the third is design implementation, finally is evaluation of the system.

The steps details are explain below:

Step One:

Review about peritoneal dialysis, the step to perform peritoneal dialysis and risk associated with peritoneal dialysis represented in peritonitis infection, causes and symptoms of the

peritonitis infection and bacteria causes infection and analysis the method was used to identify the cloudy solution.

Step Two:

Looking for suitable theory to follow it and ensure it can apply on this investigation.

Step Three:

Design a simple device to measure the turbidity of the solution and identify the cloudy solution.

Step Four:

Get an experiment reading and compare it with other review system.

1.7Research Overview:

Chapter One: This chapter introduce the kidney function, disease and treatment with a focus on peritoneal dialysis treatment and the infections associated with.

Chapter Two: This chapter represent the previous study to application of the light characteristic in the peritonitis diagnosis.

Chapter Three: This chapter review about peritonitis infection and differential diagnosis of peritonitis infection and present the scientific theory was applied in this research to achieve the desired objectives.

Chapter Four: This chapter explain the step of methodology and circuit design.

Chapter Five: This chapter clarify the experimental result and comparison with previous system result.

Chapter six: This chapter represent the conclusion and future recommendation for further research.

CHAPTER TWO

LITERATURE REVIEW

CHAPTER TWO

LITERATURE REVIEW

2.1 Rapid Spectrophotometric Detection for Analysis of Bacterial contamination In Water:

Spence in 2011[5] using optical technique to detect the bacteria in water in a little time compared to the traditional methods where they may take about 6 hours compared with 48 hours for traditional testing technique. The Beer-Lambert Law, as applied to spectrophotometric turbidity studies, correlates the concentration of organismal growth in a solution to the absorption of visible light. By passing light through a sample of contaminated broth, directly measure the intensity of the resulting light. Using this to calculate the transmittance and the absorption of light that passes through the solution. A plot of transmittance over time tracks the inverse of the bacterial growth curve. Using *Escherichia coli* (*E. coli*) as the contamination organism a sharp drop in transmittance is seen during the exponential growth phase of the bacteria being tested. This change appears within six to twelve hours following the inoculation of the *Escherichia coli* into samples, using cell counting algorithms to prove the consistency of the optical techniques with the confirmed presence of bacterial growth.

The sharp drop in transmittance was seen during the exponential growth phase of the bacteria being tested. This change was observed within six to twelve hours following the inoculation of the *Escherichia coli* into samples, using both a standard monochromator and a device engineered specifically for this study.

First to build the optical bacteria detector OBD a complete set of data encompassing all visible wave-lengths was needed to determine

specifications, and to provide a reliable baseline for how readings from the OBD should behave. UV-Vis spectrophotometry Genesys 6 was used with experimental modifications to collect and analyze data to determine the specification.

Using Genesys 6 and observe the behavior of bacteria from one initial state transplanted into a new environment, the bioreactor was used to prepare cultures in both the exponential and the stationary phases of growth. Bacteria from each initial phase was tested with the Genesys 6. Note the distinct differentiation between bacteria initially prepared in the stationary phase as opposed to bacteria prepared to be in the exponential growth phase.

Then design the Optical Bacteria Detector OBD circuit (light source+ light sensor + amplifier and delivered with voltmeter) and comparing between Genesys 6 and OBD found that OB1 reach final transmittance value of approximately 0.60 that indicate the OBD I is measuring the same properties as the Genesys-6 which was our intent. They hypothesize that the long lag time present in these samples is simply a characteristic of this culture of bacteria.

At last they was built optical bacteria detector2 OBD2 new circuit it is identical to the OBD1 though doubled to accommodate two sensors, two sensors are arranged at 180 from the light source, and another arranged at 90. The intensity of light at 180^0 and 90^0 to the incident beam was measured for each of 20 samples following 18 hours of growth. By comparing these measurements, develop a ratio of scattered light to transmitted light for E. coli in LB.

The mean value for this ratio was 0.460 to three significant figures, with a standard deviation of 0.030 to three significant figures,

when observed with the PNZ150 phototransistor and a pen laser of wavelength 523 nm.

2.2 Microbiological Aspects of Peritonitis in Patients on Continuous Ambulatory Peritoneal Dialysis: A Monocentric Five Years Follow up Study

At University Clinical Centre of Republic of Srpska, Bosnia and Herzegovina in five years period, from October 2010 till October 2015 Travar M was to analyze data about microbial cause of peritonitis in patients on CAPD [6].

In the five-year period 69 samples of peritoneal dialysate were examined. The most common isolates were Gram +ve bacteria: *Staphylococcus aureus* in 9 cases (32.1%), coagulase-negative *Staphylococcus* 5 (17.6%) and the Gram -ve bacteria *Escherichia coli* 4 (14.2%) and *Enterobacter* 3 (10.7%). In one case *Candida* spp. (3.6%) was isolated.

All the Gram positive isolates were sensitive to ciprofloxacin and vancomycin. Among *Staphylococcus* spp. There were no methicillin resistant strains. The findings of culture of peritoneal dialysate is important for the proper choice of antimicrobial therapy. The use of systemic vancomycin and ciprofloxacin administration is a simple and efficient first-line protocol antibiotic therapy for PD peritonitis.

2.3 Rapid detection of *Pseudomonas aeruginosa* by phage-capture system coupled with micro-Raman spectroscopy:

In 2016 [7] This study reports the development of a novel rapid and cultivation-free method for highly sensitive and rapid detection of *Pseudomonas aeruginosa* based on the coupling of phage-capture system with optical techniques, namely FTIR and visible micro-Raman spectroscopies.

The bacteria prepared and captured by the phage-coated beads were assessed by Fourier Transform Infrared (FTIR) and micro-Raman spectroscopies.

The sample was detected by Raman spectroscopy in the 700–1800 cm^{-1} range using an Horiba XploRa spectrometer equipped with an Olympus BX40 microscope, a Peltier cooled charge coupled device (CCD) sensor and a 532 nm laser as the excitation source. Laser radiation was focused onto the sample to a spot of 0.7 mm^2 through the 100X microscope objective lens. The spectral resolution for the Raman measurements is 2 cm^{-1} . An acquisition time of 100 s allowed a sufficient signal/noise (S/N) ratio.

The rapid concentration of bacteria enhanced the detection of the Raman scattering signal by increasing the location concentration that is being processed. This method can be used to detect a low level of *P. aeruginosa* (10³ cells/ml) from clinical samples without the use of selective media or additional biochemical tests. The sample testing process, including data acquisition, required a time less than one hour. The proposed system represents a proof of concept study for development of sensitive phage-based biosensors for rapid and specific one-step detection of pathogenic bacteria.

2.4 Diagnosis of bacterial pathogens in the dialysate of peritoneal dialysis patients with peritonitis using surface-enhanced Raman spectroscopy:

In 2016 [8] found that Surface-enhanced Raman spectroscopy (SERS) can rapidly identify bacteria using chips coated with nano-sized metal particles.

They were loaded known bacteria in the SERS-chips and illuminated with laser light to establish a reference Raman spectra library. Dialysate from PD peritonitis patients was concentrated by centrifuge and examined with the same SERS, and the resulting Raman spectra were compared with library spectra for bacteria identification. Principal component analysis was used for further confirmation. The same batches of dialysate were sent to routine culture as a reference bacteria identification method. The results of the 2 identification methods were compared.

There were 43 paired-samples used in this study. About 37 samples with bacteria identified but 6 were culture-negative by the reference method. 31 bacteria were identified in paired-samples by SERS, among which, 29 bacteria were exactly the same as those identified by the reference method. Bacteria not included in the reference library spectra cannot be identified.

SERS techniques can rapidly identify bacterial pathogens in the dialysate of PD peritonitis patients.

CHAPTER THREE

THEORETICAL BACKGROUND

HAPTER THREE

THEORETICAL BACKGROUND

Background

3.1 Peritoneal dialysis:

3.1.1 Peritoneal Dialysis Development:

The concept that the peritoneal membrane could be used as a means of removing solutes from the blood originated in the 1890s and peritoneal dialysis was first used for the treatment of renal failure in man by Ganter (1923). In the past, access to the peritoneal cavity was through several techniques and devices which needed frequent changing. 1968 saw the introduction of the Tenckhoff indwelling peritoneal catheter which had an average lifespan of approximately 20 months. This was the first permanent, relatively safe, silastic peritoneal access device [9].

In 1976 a new technique was described-Continuous Ambulatory Peritoneal Dialysis (CAPD) which allowed fluid to remain in the peritoneal cavity for 4-8h instead of an exchange of dialysate every hour. Although the Tenckhoff catheter is considered to be a permanent device, during CAPD the giving sets are changed every month, with some centres leaving them for 2 months. Originally there was poor acceptance of this new method because the dialysate was only available in glass bottles, which necessitated frequent opening of the dialysis circuit accompanied by a high incidence of peritonitis [9].

By the time the dialysate became available in plastic bags, the technique had been simplified to comprise a closed-circuit system, with a resultant reduction in peritonitis [9].

CAPD was introduced into the United Kingdom in 1978 and has since become an accepted form of dialysis treatment for patients with end-stage renal disease. More than 40 renal units now practice CAPD, accounting for 26% of the dialysis population and 14% of all patients on long-term renal replacement therapy. By 1985 it was estimated that about 27 000 patients worldwide, of whom 2450 were in the UK, were being treated by CAPD [9].

CAPD is more economical, allows greater patient mobility, does not require vascular access or any fluid and electrolyte restriction, and results in higher hemoglobin levels and better control of blood pressure[9].

The technique is especially suited to the elderly and to diabetic patients, though extra insulin is required. Young patients awaiting transplantation should, however, be offered hemodialysis. Of the infective complications which occur in CAPD, peritonitis is the most important one, though deaths from peritonitis remain relatively rare. Peritonitis remains the commonest cause of failure in CAPD treatment [9].

3.1.2Dialysate Composition:

The peritoneal dialysate is deliberately rendered hyperosmolar relative to plasma, to create an osmotic gradient that favors net movement of water into the peritoneal cavity. In commercially available peritoneal dialysates, glucose serves as the osmotic agent that enhances ultrafiltration. Available concentrations range from 1.5% to 4.25% dextrose. Over time, the osmolality of the dialysate declines as a result of water moving into the peritoneal cavity and of absorption of dialysate glucose[10].

The absorption of glucose contributes substantially to the calorie intake of patients on continuous peritoneal dialysis. Over time, this carbohydrate load is thought to contribute to progressive obesity, hypertriglyceridemia, and decreased nutrition as a result of loss of appetite and decreased protein intake. In addition, the high glucose concentrations and high osmolality of currently available solutions may have inhibitory effects on the function of leukocytes, peritoneal macrophages, and mesothelial cells [10].

The sodium concentration in the ultra-filtrate during peritoneal dialysis is usually less than that of extracellular fluid, so there is a tendency toward water loss and development of hyponatremia. Commercially available peritoneal dialysates have a sodium concentration of 132 mEq/L to compensate for this tendency toward dehydration. The effect is more pronounced with increasing frequency of exchanges and with increasing dialysate glucose concentrations [10].

Potassium is cleared by peritoneal dialysis at a rate similar to that of urea. With chronic ambulatory peritoneal dialysis and 10 L of drainage per day, approximately 35 to 46 mEq of potassium is removed per day. Daily potassium intake is usually greater than this, yet significant hyperkalemia is uncommon in these patients. Presumably potassium balance is maintained by increased colonic secretion of potassium and by some residual renal excretion. Given these considerations, potassium is not routinely added to the dialysate [10].

The buffer present in most commercially available peritoneal dialysate solutions is lactate. In patients with normal hepatic function, lactate is rapidly converted to bicarbonate, so that each mM of lactate absorbed generates one mM of bicarbonate [10].

Even with the most aggressive peritoneal dialysis there is no appreciable accumulation of circulating lactate. The rapid metabolism of lactate to bicarbonate maintains the high dialysate-plasma lactate gradient necessary for continued absorption [10].

The pH of commercially available peritoneal dialysis solutions is purposely made acidic by adding hydrochloric acid to prevent dextrose from caramelizing during the sterilization procedure. Once instilled, the pH of the solution rises to values greater than 7.0. There is some evidence that the acidic pH of the dialysate, in addition to the high osmolality, may impair the host's peritoneal defenses [10].

To avoid negative calcium balance and possibly to suppress circulating parathyroid hormone commercially available peritoneal dialysis solutions evolved to have a calcium concentration of 3.5 mEq/L (1.75 mmol/L). This concentration is equal to or slightly greater than the ionized concentration in the serum of most patients. As a result, there is net calcium absorption in most patients treated with a conventional chronic ambulatory peritoneal dialysis regimen [10].

As the use of calcium containing phosphate binders has increased, hypercalcemia has become a common problem when utilizing the 3.5 mEq/L calcium dialysate. This complication has been particularly common in patients treated with peritoneal dialysis. As a result, there has been increased interest in using a strategy similar to that employed in hemodialysis, namely, lowering the calcium content of the dialysate. This strategy can allow increased use of calcium containing phosphate binders and more liberal use of 1.25-dihydroxyvitamin D to effect decreases in the circulating level of parathyroid hormone. In this way, development of hypercalcemia can be minimized [10].

3.1.3 Peritoneal Dialysis Infection:

Peritoneal dialysis is simple and practical method of treatment, special care must be taken by PD patients and their medical providers to prevent infection because a soft tube (catheter) is present in the abdominal cavity for this treatment[11].

[1] Catheter Infection (exit site and tunnel infection):

An exit-site infection is defined by the presence of purulent drainage, with or without erythema of the skin at the catheter epidermal interface. Pericatheter erythema without purulent drainage is sometimes an early indication of infection but can also be a simple skin reaction, particularly in a recently placed catheter or after trauma to the catheter [11].

A tunnel infection may present as erythema, edema, or tenderness over the subcutaneous pathway but is often clinically occult, as shown by sonographic studies. A tunnel infection usually occurs in the presence of an exit-site infection but rarely occurs alone. In the present article, exit-site and tunnel infections are collectively referred to as catheter infections [11].

[2] Peritonitis Infection:

Peritonitis remains a leading complication of peritoneal dialysis (PD). Around 18% of the infection-related mortality in PD patients is the result of peritonitis. Although less than 4% of peritonitis episodes result in death, peritonitis is a “contributing factor” to death in 16% of deaths on PD. In addition, severe and prolonged peritonitis can lead to peritoneal membrane failure and peritonitis is probably the most common cause of technique failure in PD. Peritonitis remains a major cause of patients discontinuing PD and switching to hemodialysis [11].

Peritonitis does not have the classical clinical presentation of surgical peritonitis with rigid abdomen, toxic symptoms and septicemia. Characteristically, CAPD peritonitis is a mild illness, the predominant feature of which is a “cloudy bag” caused by the presence of large numbers of white cells, usually in excess of 100 cells/mm³. This may be accompanied by mild fever, abdominal pain and tenderness, with occasional difficulty in draining the exchange fluid. Positive blood cultures are extremely rare [9]. The incubation period of peritonitis is uncertain, probably only 1-2 days. Symptoms usually disappear within 48h following the instigation of appropriate antimicrobial treatment. It is probable that only small numbers of micro-organisms are necessary to produce peritonitis, but that not all episodes of microbial contamination lead to peritonitis. The principal portal of entry for organisms (figure 3.1) is thought to be the lumen of the catheter. The commercial production of peritoneal dialysate under stringent quality control criteria makes this fluid an unlikely source of bacteria [9].

Therefore, the PD community continues to focus attention on prevention and treatment of PD-related infections. Peritonitis treatment should aim for rapid resolution of inflammation and preservation of peritoneal membrane function [11].

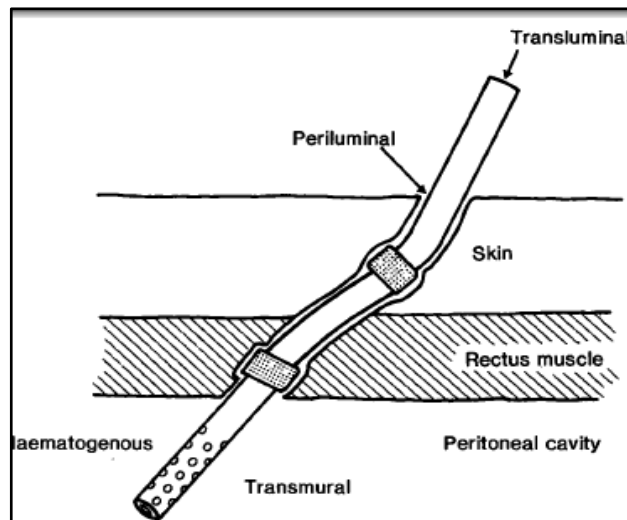


Figure 3.1:explain the entry of the catheter in the skin and how the organism can enter through the luminal [9]

Common symptoms of peritonitis are:

- 1- Abdominal pain.
- 2- Abdominal tenderness.
- 3- Abdominal distention.
- 4- Cloudy PD fluid.
- 5- Fever.
- 6- Nausea and vomiting[12].

3.1.4 Bacteria causes peritonitis infection:

University Clinical Centre of Republic of Srpska, Bosnia and Herzegovina from October 2010 till October 2015 study and analyze data about microbial cause of peritonitis in patients on CAPD on 69 samples of peritoneal dialysate and found that The most common isolates were Gram +ve bacteria: *Staphylococcus aureus* in 9 cases (32.1%), coagulase-negative *Staphylococcus* 5 (17.6%) and the Gram -ve bacteria *Escherichia coli* 4 (14.2%) and *Enterobacter* 3 (10.7%). In one case *Candida* spp. (3.6%) was isolated. The results were shown on table 1[6].

Table 3.1: Isolates from the peritoneal fluid in patients on peritoneal dialysis with peritonitis monitored in University Clinical Centre of Republic of Srpska from 2010 till 2015

Isolates	-	%
Staphylococcus aureus	9	32.1%
coagulase-negative Staphylococcus	5	17.9%
Streptococcus viridans	1	3.6%
Erysipelotrixrhusiopathiae	1	3.6%
Gram Positive (total)	16	57.2%
Escherichia coli	4	14.2%
Enterobacter	3	10.7%
Pseudomonas aeruginosa	2	7.1%
Klebsiellapneumonia	1	3.6%
Haemophilus influenza	1	3.6%
Gram Negative (total)	11	39.2%
Candida spp	1	3.6%
Total	28	100%

3.1.5 Diagnosis of peritonitis:

Patients with peritonitis usually present with cloudy fluid and abdominal pain; however, peritonitis should always be included in the differential diagnosis of the cloudy effluent [11].

PD patient with abdominal pain, even if the effluent is clear, as a small percentage of patients present in this fashion. Other causes, such as constipation, renal or biliary colic, peptic ulcer disease, pancreatitis, and acute intestinal perforation, should also be investigated in the PD patient with abdominal pain and clear fluid [11].

Conversely, while patients with peritonitis most often have severe pain, some episodes are associated with mild or even no pain. The

degree of pain is somewhat organism specific (e.g., generally less with CoNS and greater with Streptococcus, gram-negative rods, S. aureus) and can help guide the clinician in the decision to admit or treat as an outpatient. Patients with minimal pain can often be treated on an outpatient basis with IP therapy and oral pain medication. Those requiring intravenous (IV) narcotics always require admission for management. Cloudy effluent will usually represent infectious peritonitis but there are other causes [11].

Differential Diagnosis of Cloudy Effluent:

- Culture-positive infectious peritonitis.
- Infectious peritonitis with sterile cultures.
- Chemical peritonitis.
- Eosinophilia of the effluent.
- Hemoperitoneum.
- Malignancy (rare).
- Chylous effluent (rare).
- Specimen taken from “dry” abdomen [11].

Case reports of sterile peritonitis associated with icodextrin-based dialysis solutions have been reported from Europe. Randomized trials comparing icodextrin- to glucose-based dialysis solutions show similar peritonitis risk with the two solutions. The abdomen should be drained and the effluent carefully inspected and sent for cell count with differential, Gram stain, and culture. An effluent cell count with white blood cells (WBC) more than 100/mL (after a dwell time of at least 2 hours), with at least 50% polymorph nuclear neutrophilic cells, indicates the presence of inflammation, with peritonitis being the most likely cause. To prevent delay in treatment, antibiotic therapy should be initiated as soon as cloudy effluent is seen, without waiting for confirmation of the cell count from the laboratory [11].

Patients with cloudy effluent may benefit from the addition of heparin (500 units/L) to the dialysate to prevent occlusion of the catheter by fibrin. Heparin is also usually added in cases of hemoperitoneum. An experienced observer can differentiate hemoperitoneum from cloudy effluent due to peritonitis. If there is a question, a cell count with differential should be performed[11].

The number of cells in the effluent will depend, in part, on the length of the dwell. For patients on automated PD (APD) who present during their nighttime treatment, the dwell time is much shorter than with continuous ambulatory PD (CAPD); in this case, the clinician should use the percentage of polymorph nuclear cells rather than the absolute number of white cells to diagnose peritonitis. The normal peritoneum has very few polymorph nuclear cells; therefore, a proportion above 50% is strong evidence of peritonitis, even if the absolute white cell count does not reach 100/mL. Patients on APD with a day dwell who present during the day generally have cell counts similar to those of CAPD patients and are not difficult to interpret. However, APD patients without a daytime exchange who present with abdominal pain may have no fluid to withdraw. In this case, 1 L of dialysate should be infused and permitted to dwell a minimum of 1 – 2 hours, then drained and examined for turbidity, and sent for cell count with differential and culture. The differential (with a shortened dwell time) may be more useful than the absolute WBC count. In equivocal cases, or in patients with systemic or abdominal symptoms in whom the effluent appears clear, a second exchange is performed with a dwell time of at least 2 hours. Clinical judgment should guide initiation of therapy [11].

Even though the Gram stain is often negative in the presence of peritonitis, this test should be performed as the Gram stain may indicate

the presence of yeast, thus allowing for prompt initiation of antifungal therapy and permitting timely arrangement of catheter removal [11].

With this exception, empiric therapy should not be based on the Gram stain but should cover the usual pathogens, as discussed below [11].

The patient should always be questioned in a nonthreatening manner about a break in technique and in particular whether contamination or disconnection occurred recently. Information about recent exit-site infections and the last (if any) episode of peritonitis should be obtained. The patient should also be questioned about any recent endoscopic or gynecological procedures, as well as the presence of either constipation or diarrhea [11].

In peritonitis, abdominal tenderness is typically generalized and is often associated with rebound. Localized pain or tenderness should raise the suspicion of an underlying surgical pathology such as acute appendicitis. The physical examination of the patient presenting with peritonitis should always include a careful inspection of the catheter exit site and tunnel. Any drainage from the exit site should be cultured along with the effluent. If the exit site grows the same organism as the effluent (with the exception of CoNS), then it is very likely that the origin of the peritonitis is the catheter [11].

Although an abdominal x-ray image is generally not necessary, if there is any suspicion of a bowel source, an abdominal film should be obtained. The presence of free air under the diaphragm is suggestive of perforation, although it should be noted that a small amount of IP air is common among PD patients due to inadvertent infusion of air by the patient. Routine peripheral blood cultures are unnecessary since they are

usually negative but they should be obtained if the patient appears septic [11].

Some PD patients reside in locations that are remote from medical facilities and thus cannot be seen expeditiously after the onset of symptoms. These patients also may not have immediately available microbial and laboratory diagnostic services. Since prompt initiation of therapy for peritonitis is critical, this necessitates reliance on immediate patient reporting of symptoms to the center, and then initiating IP antibiotics in the home setting. Such an approach requires that the patients be trained in this technique and that antibiotics be kept in the home. A delay in treatment could be dangerous [11].

Whenever possible, prior to starting antibiotic, cultures should be obtained either at a local facility or by having the patient keep blood-culture bottles at home for use [11].

Alternatively, the patient may place the cloudy effluent bag in the refrigerator to slow bacterial multiplication and white cell killing until they are able to bring in the sample. The benefit of self-initiated treatment, however, should be carefully balanced against the potential problems of over diagnosis and habitual misuse of antibiotics [11].

[1] Specimen processing:

Culture-negative peritonitis should not be greater than 20% of episodes. Standard culture technique is the use of blood-culture bottles but a large-volume culture (e.g., culturing the sediment after centrifuging 50 mL of effluent) could further improve the recovery of micro-organisms [11].

In the ideal situation (e.g., in specialized academic centers), one could achieve a less than 10% rate of culture- negative peritonitis. Correct microbiological culturing of peritoneal effluent is of utmost importance to establish the micro- organism responsible. Identification of the organism and subsequent antibiotic sensitivities will not only help guide antibiotic selection but, in addition, the type of organism can indicate the possible source of infection [11].

An optimal culture technique is the combination of sediment culturing of 50 mL effluent and bedside inoculation of 5 – 10 mL effluent in two blood culture bottles [11].

The specimens should arrive within 6 hours at the laboratory. If immediate delivery to the laboratory is not possible, the inoculated culture bottles should ideally be incubated at 37°C. When the causative micro-organism has been established, subsequent cultures for monitoring may be performed by only inoculating the effluent in blood-culture bottles. Centrifugation of 50 mL peritoneal effluent at 3000g for 15 minutes, followed by re suspension of the sediment in 3 – 5 mL of sterile saline, and inoculation of this material both on solid culture media and into a standard blood-culture medium, is a sensitive method to identify the causative organisms. With this method, less than 5% will be culture negative. The solid media should be incubated in aerobic, microaerophilic, and anaerobic environments [11].

Blood-culture bottles can be directly injected with 5 –10 mL of effluent if equipment for centrifuging large amounts of fluid is not available; this method generally results in a culture-negative rate of 20%. If the patient is already on antibiotics, removal of antibiotics present in the specimen may increase the isolation rate [11].

The speed with which bacteriological diagnosis can be established is very important. Concentration methods not only facilitate correct microbial identification but also reduce the time necessary for bacteriological cultures. Rapid blood-culture techniques (e.g., BACTEC, Septi-Chek, BacT/Alert; Becton Dickinson) may further speed up isolation and identification and are probably the best approach. Two recent prospective studies also support the routine use of the broth culture technique, while the lysis–centrifugation technique needs [11]

Further evaluation. The majority of cultures will become positive after the first 24 hours and, in over 75% of cases, diagnosis can be established in less than 3 days. When cultures remain negative after 3 – 5 days of incubation and clinical suspicion is high, subculture of blood-culture bottles on media with aerobic, anaerobic, and microaerophilic incubation conditions for a further 3 – 4 days may help to identify slow-growing bacteria and yeasts that are undetectable in an automated culture system [11].

[2]Other novel diagnostic technique:

There is not enough evidence for recommending the use of novel techniques [such as leukocyte esterase, broad-spectrum polymerase chain reaction (PCR), quantitative bacterial DNA PCR] for the diagnosis of peritonitis [11].

A number of novel diagnostic techniques have been explored for the early diagnosis of peritonitis. Park and Akman [11] reported that leukocyte esterase reagent strip has excellent accuracy for the diagnosis of peritonitis. Various commercially available strips have been tested to diagnose non-PD peritonitis but the results vary enormously; more studies are required before this can be applied in a routine setting. Broad-

spectrum PCR with RNA sequencing and quantitative bacterial DNA PCR assays may also complement culture methods in the diagnosis of CAPD peritonitis, especially in patients with previous or current antibiotic use.

The latter technique may also help to identify those patients likely to relapse despite apparent clinical improvement with standard antibiotic therapy. Another study suggests that the matrix metalloproteinase-9 test kit may be a reliable method for early diagnosis of PD peritonitis. The role of rapid detection of the causative pathogen of peritonitis using in situ hybridization has also been explored [11].

From the above studies from 1988 until now cloudy bag is an important sight for peritonitis infection and useful indicator for other diagnosis of infection, because that the ability of differentiate between cloudy and not cloud solution very important.

3.2 The Nature and Properties of Light

light is a special kind of electromagnetic energy, travels in a vacuum at a constant speed expressed as $c = 2.99 \times 10^8$ m/s. and speed changes for light traveling through non vacuum media such as air (0.03% slower) or glass (30.0% slower) [13].

In a vacuum, light will travel in a straight line at fixed speed, carrying energy from one place to another. Two key properties of light interacting with a medium are [13]:

1. It can be deflected upon passing from one medium to another (refraction).
2. It can be bounced off a surface (reflection).

When light travels through a medium, it interacts with the medium. The important interactions are absorption and scattering[13].

3.2.1 Absorption:

Absorption is a transfer of energy from the electromagnetic wave to the atoms or molecules of the medium. Energy transferred to an atom can excite electrons to higher energy states. Energy transferred to a molecule can excite vibrations or rotations. The wavelengths of light that can excite these energy states depend on the energy-level structures and therefore on the types of atoms and molecules contained in the medium. The spectrum of the light after passing through a medium appears to have certain wavelengths removed because they have been absorbed. This is called an absorption spectrum [13].

Selective absorption is also the basis for objects having color. A red apple is red because it absorbs the other colors of the visible spectrum and reflects only red light [13].

3.2.2 Scattering

Scattering is the redirection of light caused by the light's interaction with matter. The scattered electromagnetic radiation may have the same or longer wavelength (lower energy) as the incident radiation, and it may have a different polarization [13].

If the dimensions of the scatterer are much smaller than the wavelength of light, like a molecule, for example, the scatterer can absorb the incident light and quickly reemit the light in a different direction. If the reemitted light has the same wavelength as the incident

light, the process is called *Rayleigh scattering*. If the reemitted light has a longer wavelength, the molecule is left in an excited state, and the process is called Raman scattering. In Raman scattering, secondary photons of longer wavelength are emitted when the molecule returns to the ground state [13].

If the scatterer is similar in size to/or is much larger than the wavelength of light, matching energy levels is not important. All wavelengths are equally scattered. This process is called Mie scattering. Water droplets effectively scatter all wavelengths of visible light in all directions [13].

Both of the above mentioned interactions will cause a light beam to be attenuated when passing through a solution¹ of particles (see figure 3.2). It doesn't matter whether light is being attenuated by scattering or absorption: In both cases the transmitted intensity will decrease exponentially with the thickness x of the material the light is passing through. If the attenuation is due to absorption the transmitted intensity I is usually written [14]

$$I = I_0 \cdot 10^{-\alpha x} \quad (1)$$

Whereas if the attenuation is due to scattering the intensity is written:

$$I = I_0 \cdot e^{-\tau x} \quad (2)$$

Where I_0 is the incident intensity (i.e. before attenuation). The quantities α and τ are called the absorption coefficient and the turbidity, respectively. The two different bases (e and 10) for the exponential decays are merely a matter of convention [14].

Light scattering methods can provide information about the native molecular weight, oligomeric composition, and gross conformation of a

protein in solution. These methods are particularly well suited for studying large oligomeric systems or glycoproteins and can be used to characterize much larger structures involving protein such as viruses and even bacterial spore[15].

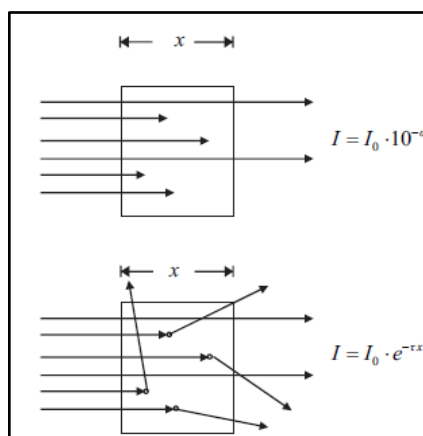


Figure 3.2: The transmitted light is weakened by either absorption (top) or by scattering (bottom).

All light scattering measurements on solutions of proteins and protein assemblies are based on the principle of analyzing the intensity of light scattered by the solution, either in terms of the time-averaged intensity ('classical' or 'static' light scattering) or intensity fluctuations with time ('dynamic' or 'quasielastic' light scattering) at a given angle or series of angles [15].

There are three types of 'static' light scattering experiment:

1. Turbidimetry, which is simple but gives only crude molecular-weight estimates for large assemblies;
2. Low-angle light scattering which is also simple and gives molecular-weight and molecular weight-distribution information;
3. Multi angle light scattering, which gives more reliable molecular-weight and molecular weight distribution information [15].

Turbidimetry:

Turbidimetry involves the measurement of the total loss of intensity by a solution through scattering, summed over the entire angular intensity envelope and compared with the intensity of the incident radiation [15].

Turbidimetry resulting from the interaction of incident light with particulate material in a liquid sample. Typically, the liquid is a water sample and the suspended material causing the light to be scattered can be composed of a broad variety of components. Examples of particles include: suspended solids such as silt, clay, algae, organic matter, various microorganisms, colloidal material, and even large molecules that are dissolved in the sample such as tannins and lignins [18].

It can be used to measure the molecular weights of protein assemblies of $M > 10^5$ Da, Measurements have to be made at wavelengths away from the influence of absorption maxima [15].

The turbidity of a suspension is defined as the fractional loss of intensity I of an incident beam by scattering per unit path length (x) of the suspension [16]

$$\tau = -(dI/dx)/I \quad (3)$$

τ Can be related to the "optical density" (OD) via:

$$\tau = 2.303 \cdot (OD) \quad (4)$$

The turbidity is normally measured relative to the suspending and can be related to the M_r of the scatterer via medium or solvent [16]

$$\tau = M_r \cdot c \cdot H \cdot Q(\lambda) \quad (5)$$

$$H = 32\pi^3 (\frac{d}{\lambda_0})^2 / 3N_A \lambda_0^4 \quad (6)$$

In these equations c is the concentration (g/ml), n the refractive index, N_A Avogadro's number, λ_0 the wavelength in vacuo, and Q the particle dissipation factor ; that is, a dimensionless number between 0 and 1 which depends on the dimensions of the scattering particle relative to the wavelength through the medium, λ [16]:

$$Q = \frac{3}{8} \int_0^\pi P(\theta)(1 + \cos^2 \theta) \sin \theta d\theta \quad (7)$$

Where θ is the scattering angle and $P(\theta)$ is the ratio of the actual scattered intensity of a particle to the scattered intensity without interference. The $P(\theta)$ values-and hence Q values for a wide range of particle shapes-have been worked out by Doty and Steiner based on the assumption that contributions from $P(\theta)$ are solely from intraparticle interference effects and that there are no significant changes in phase of the light passing through the particle (this is known as the Rayleigh-Gans-Debye (RGD) approximation). Camerini Otero and Day have used a series expansion for $P(\theta)$ given by Debye to produce a general expression for Q for any shape of scatterer [16]

$$Q = 1 - \sum_{n=1}^{\infty} \alpha_n - 1^{n+1} \cdot q_{2n} \left(\frac{4\pi d}{\lambda} \right)^{2n} \quad (8)$$

Where d is its "principal dimension" (viz., length for a rod radius for a sphere, or the root mean square end-to-end distance for a random coil) and the coefficients q_{2n} , have been tabulated, enabling simple computer evaluations of Q [16].

When the shape of a scatterer is not known an estimate for Q can be obtained from the wavelength dependence of the turbidity:

$$\frac{-d \log \tau}{d \log \lambda_0} = 4 - \beta \quad (9)$$

Where $\beta = (d \log Q / d \log I_0)$. β can therefore be estimated from a double logarithmic plot of τ vs λ . Once β is determined, Q can be obtained from the tables of Doty and Steiner. The assumption is of course made that loss of intensity is due to scattering and not absorbance. This method of determining the molecular weight after allowance for intraparticle interference (via Q) is only rigorous in the absence of interparticle interference effects: strictly speaking the "apparent M_r " measured at a finite concentration needs to be extrapolated to infinite dilution, which is why Eq. [5] is often rewritten in the form [16]:

$$\frac{1}{M_r} = HQ \lim_{c \rightarrow 0} \frac{c}{r} \quad (10)$$

Application to Bacteria:

Turbidimetry has been applied to both the vegetative cells and spores of bacteria, with the aim of (i) estimating the concentrations of microorganisms and (ii) estimating their masses. It is a particularly simple and useful technique for monitoring changes in numbers and masses [16].

Although bacteria normally scatter more strongly than viruses, theoretical interpretation of the data is more difficult since the limits of the RGD approximation-which assumes that phase changes of the scattered light are negligible-may be exceeded [16].

This approximation is valid provided that the following condition is met:

$$\frac{4\pi nd}{\lambda_0} \left(\frac{n}{n_0} - 1 \right) \ll 1 \quad (11)$$

Where d is the maximum dimension of the particle, n its refractive index, and n_0 the refractive index of the suspending medium. However,

Koch has pointed out that for vegetative bacterial cells this criterion may not be satisfied, because of the high refractility of the outer membrane, and for bacterial spores, the dehydrated protoplast. However, the major influence of the phase-shift is to the direction in which scattered wavelets most strongly interfere without influencing the total amount of interference and hence the turbidity. For bacteria, an equation equivalent to Eq. (5) and (6) has been used [16]:

$$(OD) = \frac{\tau}{2.303} = \frac{32\pi^3 \Theta / \Theta^2}{3\lambda_0^4} [q^2] Q(12)$$

Where v is the number concentration of particles (ml^{-1}), q is the anhydrous mass of a single particle (g), and $q^2 v = M_r c / N_A$. For near-spherical bacteria, Q has been taken to be unity. This equation proves the truth of the general impression among bacteriologists that turbidity is a more sensitive measure of the total mass or volume of bacteria in a sample than the number concentration. Thus it provides a very useful technique for monitoring the growth of bacteria [16].

3.3 The linear discriminant analysis (LDA):

Discriminant analysis DA involves the determination of a linear equation like regression that will predict which group the case belongs to. The form of the equation or function is:

$$D = v_1 X_1 + v_2 X_2 + v_3 X_3 = \dots v_i X_i + a$$

Where D = discriminate function

v = the discriminant coefficient or weight for that variable

X = respondent's score for that variable

a = a constant

i = the number of predictor variables[17]

These v 's maximize the distance between the means of the criterion (dependent) variable. Good predictors tend to have large weights.

A discriminant score. This is a weighted linear combination (sum) of the discriminating variables[17].

Discriminant analysis (DA) purpose:

1. To investigate differences between groups on the basis of the attributes of the cases, indicating which attributes contribute most to group separation. The descriptive technique successively identifies the linear combination of attributes known as canonical discriminant functions (equations) which contribute maximally to group separation.

2. Predictive DA addresses the question of how to assign new cases to groups. The DA function uses a person's scores on the predictor variables to predict the category to which the individual belongs.

3. To determine the most parsimonious way to distinguish between groups.

To classify cases into groups. Statistical significance tests using chi square enable you to see how well the function separates the groups.

5. To test theory whether cases are classified as predicted [17].

Discriminant analysis – creates an equation which will minimize the possibility of misclassifying cases into their respective groups or categories [17].

Discriminant analysis was used in this research to classify between 2 group normal and infection and to create the classification function.

CHAPTER FOUR

METHODOLOGY

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METHODOLOGY

4.1 Data Collection:

First looking for suitable theory to follow it (the dialysate is contain many substance so the absorption theory was avoided) select light scattering .the intensity of the scattering light determine the turbidity of the solution.

Then Collect the data about peritoneal dialysis in Sudan and the number of patient under the program, found that peritoneal dialysis treatment is in 3 hospital (Military Hospital Helipad, Ribat University Hospital and Soba University Hospital), they are 57 patient using peritoneal dialysis in Sudan, and they are distributed in different states.

Table4.1: illustrate the peritoneal dialysis patient distribution in hospitals

Hospital Name	Number of Patient
Military hospital helipad	7
Ribat university hospital	22
Soba university hospital	28

Select 14patient (5 female, 9 male) different age and easy to arrive.

The dianeal solution (yellow and green) are most used with glucose rate(1,5and 2.25) in Sudan, and elderly patients who have difficulty in movement are used Extraneal with purple colour code, patient have peritonitis infection using only dianeal yellow with 1.5 rate

of glucose because glucose is appropriate medium for bacteria growth for more information about the solution and codes see appendix (1)

From the previous study and hospital (nurse and lab) staphylococcus, E.coli and pseudomonas are common bacteria causes peritonitis infection, using standard bacteria American Type Culture Collection(ATCC) from National public health laboratory (STAC)

From the above information 14 patient 5female and 9male in different age and easy to arrive, dialysate yellow and green and staphylococcus 25923, E.coli 25422 and pseudomonas 27853 standard bacteria was used in this study.

4.2 Theory Examination on used Dialysate by using Turbidimetry on STAC.

In this step measure the turbidity of the fresh dialysate and used dialysate to the dialysate with (1.5 and 2.25) glucose concentration and extraneal solution in the National Public Health Laboratory by using turbidimeter in the water and chemical department.

Also we have acquired some of the infected samples but had passed on the infection several days, less time was 6days.

Knowing that after two days of starting treatment the peritonitis infection begins to disappear from patient and used dialysate return to be normal not cloud.

4.3 Implementation the Device:

Using 2 light emitting diode(LED), 2 detector light dependent resistor (LDR), sample container, micro controller (atmega 16), display unit (LCD), buzzer with driver with power supply 5 m volt as we see below

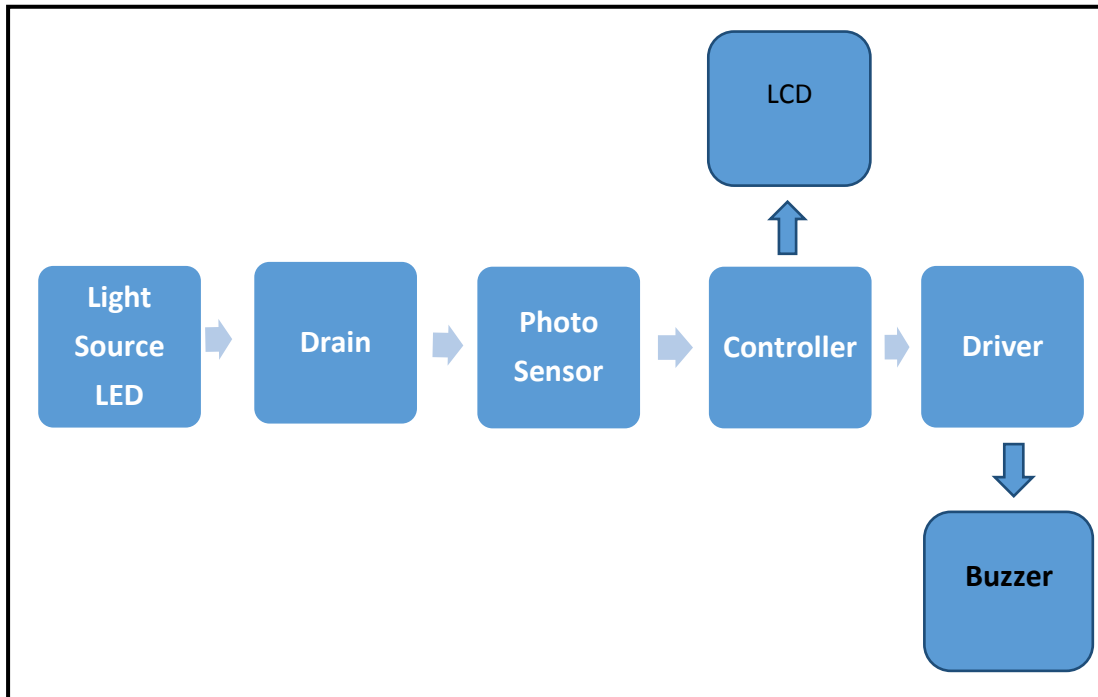


Figure 4.1: illustrate the block diagram of the proto type composition

Light source (LED):

A light emitting diode (LED) is a device which converts electrical energy to light energy.

LEDs are preferred light sources for short distance (local area) because LEDs are cheap, robust and have long life.

A Light emitting diode (LED) is essentially a p-n junction diode. When carriers are injected across a forward-biased junction, it emits incoherent light. Most of the commercial LEDs are realized using a highly doped n and a p Junction (19).

In general, LEDs require a forward operating voltage of approximately 1.5–3 V and a forward current ranging from 10 to 30 mA, with 20 mA being the most common current they are designed to support. Both the forward operating voltage and forward current vary depending on the semiconductor material used (20).

Drain Container:

A glass tube of scale 10ml to 50ml

Photo Sensor:

A light dependent resistor also known as a LDR, photo resistor, photoconductor or photocell, is a resistor whose resistance increases or decreases depending on the amount of light intensity. LDRs (Light Dependent Resistors) are a very useful tool in a light/dark circuits. A LDRs can have a variety of resistance and functions

An LDR may typically have the following resistances:

Daylight = 5000Ω

Dark = $20000000\ \Omega$ (21, 22).

Micro Controller:

A microcontroller often serves as the “brain” of a mechatronic system. Like a mini, self-contained computer, it can be programmed to interact with both the hardware of the system and the user. Even the most basic microcontroller can perform simple math operations, control digital outputs, and monitor digital inputs (23).

ATmega16 is an 8-bit high performance microcontroller of Atmel’s Mega AVR family with low power consumption. Atmega16 is based on enhanced RISC (Reduced Instruction Set Computing) architecture with 131 powerful instructions. Most of the instructions execute in one machine cycle. Atmega16 can work on a maximum frequency of 16MHz.

ATmega16 has 16 KB programmable flash memory, static RAM of 1 KB and EEPROM of 512 Bytes. The endurance cycle of flash memory and EEPROM is 10,000 and 100,000, respectively.

ATmega16 is a 40 pin microcontroller. There are 32 I/O (input/output) lines which are divided into four 8-bit ports designated as PORTA, PORTB, PORTC and PORTD.

ATmega16 has various in-built peripherals like USART, ADC, Analog Comparator, SPI, JTAG etc. Each I/O pin has an alternative task related to in-built peripherals, more information in appendix (2)

Display Unit:

Liquid Crystal Display (LCD)

Liquid Crystal Display (LCD) technology is a flat panel display, it has rapidly become a significant component of modern electronics. It offers solution to the rising need of low power-consuming, space-saving and better display devices, Liquid crystal (LC) exhibits both the properties of liquid and solid states. All the molecules in LC tend to align in the same specific direction, which enables them to flow as a liquid. LC are affected by electrical current and can exist in several distinct phases with varying temperature (25).

They can present textual information to user, and come in various types. The most popular one is 16x2 LCD Module. It has 2 rows and 16 columns.

Alphanumeric displays are used in a wide range of applications, including palmtop computers, word processors, photocopiers, point of sale terminals, medical instruments, cellular phones, etc. The 16 x 2

intelligent alphanumeric dot matrix display is capable of displaying 224 different characters and symbols.

Its Serial LCD Firm ware, allows serial control of the display. Which provides much easier connection and use of the LCD module. The firmware enables microcontrollers (and microcontroller based systems such as the PICAXE) to visually output user instructions or readings onto an LCD module. All LCD commands are transmitted serially via a single microcontroller pin. The firmware can also be connected to the serial port of a computer more information appendix(3)

Buzzer:

A buzzer or beeper is an audio signaling device, which may be mechanical, electromechanical, or piezoelectric. Typical uses of buzzers and beepers include alarm devices, timers and confirmation of user input such as a mouse click or keystroke.

It is commonly consists of a number of switches or sensors connected to a control unit. The control unit finds the types of button were pushed or a preset time has lapsed, and usually illuminates a light on the appropriate button or control panel. Then it creates warning sounds. This device was based on an electromechanical system which was identical to an electric bell without the metal gong (which makes the ringing noise) (26).

Buzzer is an integrated structure of electronic transducers, DC power supply. Active buzzer 5V Rated power can be directly connected to a continuous sound appendix (4).

Driver:

Is an electrical circuit or other electronic component used to control another circuit or component such as liquid crystal display.

They are usually used to regulate current flowing through a circuit or to control other factors such as other component.

4.4 Test the Implemented Device in Analog Step.

The circuit was tested through samples of yellow and green solution and see the effect of bacteria on the solution in term of turbidity.

In this step we are take fresh dialysate and sub culturing and confirmed the growth of bacteria in the solution in the laboratory. Where that prove the dialysate is a suitable medium for growth of bacteria.

Using dianeal fresh dialysate (yellow green) (1.5&2.25) to test the operation of the device, take a 2 sample from yellow one was read directly and the second was sub culturing and then was reading. And repeated the same process with the green solution. The result was obtained in table (5.1).

We needed to see if there was the impact of the different types of bacteria on turbidity measurement so we took three samples from fresh dialysate (yellow solution with 1.5 glucose concentration) and sub culturing with 3 different types of bacteria as shown in table(5.2).

4.5 Samples Measurement.

In this step worked to identify a certain extent for normal and infected sample.

Collect the samples from patient in their home, follow the dialysis process and take sample about 60ml in sterilize container.

Due to the small number of patients and the lack of risk of inflammation when taking the necessary precautions. difficult to find sample with peritonitis infection so we took 2 samples from patient one for direct reading and second for culturing and reading after culturing .

sub culturing was done in the lab of Omer Sawa hospital, which is done under flame using probe by expose the probe to the flame for sterilize and took some of bacteria one from 3 type and put it on the solution .and put the solution in incubator for 24h and then reading the turbidity by the device .

Using about 40ml from the sample with power 5mv and then register the reading.

4.6 Samples Readings Analysis.

Using linear discriminant analysis from the SPSS program to determine the normal range and distinguish it from the infection range by finding the classification function. By taking the sensors (upper and lower) reading and solution colour as independent variable and the presence of bacteria whether or not as grouping variable.

Apply the linear discriminant analysis on the 180 samples (yellow, green, with and without bacteria) and we have a comprehensive statistical analysis and the classification function was determined as we see in the next chapter.

Before the linear discriminant analysis we are using the fuzzy logic and neural network and tried several independent variable in the linear discriminant analysis.

4.7 Device Evaluation with turbidimetry.

24 sample was reading at the same time by turbidimeter and device was implemented to determine whether the implemented device capable of measuring light scattering (the turbidity).

24 samples (yellow and green), 12 was reading directly and 12 was reading after sub culturing by same type of standard bacteria (staphylococcus 25923, E.coli 25422 and pseudomonas 27853) as we see in figure (5.1, 5.2).

The turbid-meter with accuracy $\pm 2\%$ of reading plus 0.01NTU from 0-1000NTU, $\pm 5\%$ of reading from 1000 to 4000NTU with resolution 0.001 on lowest range. Light source is a tungsten filament lamp, lamp life 8,800hours.

CHAPTERFIVE

RESULT AND DISCUSSION

CHAPTER FIVE

RESULT AND DISCUSSION

In this chapter we offer and discuss the results that we have acquired them at every step as we explained it later in developed parts.

Firstly test the possibility of using scattering theory to detect the clouds by examining 17 sample by turbidity measurement device we can observe the difference in fresh and used dialysate measurement. From the result in appendix (5):

Yellow solution with lowest concentration of glucose is low turbidity then the green solution and extraneal purple with high turbidity.

Turbidity was increased with used dialysate because the waste, water and minerals from the body and the dianeal (yellow 1.25) has low range of turbidity and extraneal has high range of turbidity even with used dialysate

There are four samples of peritonitis infection, the turbidity is high even it passed long time , shortly time passed is six day, when patient begin the treatment and take the antibiotic the peritonitis infection decrease and the infection begin to disappear ,during 48 hours the turbidity semi disappear.

Secondly test the ability of the implemented device to detect the turbidity after sub culturing the sample solution.

From the result in table (5.1) we can observe the different in sample before and after culturing.

Difference in reading mean the bacteria was growth and the device capable to detect the turbidity resulting from the growth of bacteria in yellow and green solution.

We can observe different in readings between yellow and green solution with and without bacteria it is not big different but it was observant.

Table 5.1: explain the effect of bacteria in yellow and green solution.

With bacteria				Without bacteria				solution
upper		Lower		upper		Lower		
2	1	2	1	2	1	2	1	
2.27	2.233	2.767	2.863	2.126	2.185	2.884	2.813	Green
2.081	2.023	2.754	2.725	1.847	1.866	2.656	2.680	Yellow

After knowing more types of bacteria causing the infection, we wanted to know if it was different type of bacteria change in value of turbidity and from the readings in table (5.2) we notice there is no an observable different in the result of turbidity.

Table 5.2:explain the result of turbidity of yellow solution culturing with (Cripsala, Ecoli, and S.aureus).

Lower detector		Upper detector		Type of bacteria
2	1	2	1	
2.688	2.767	2.117	2.135	Cripsala1
2.752	2.756	2.0	2.012	Cripsala2
2.795	2.791	2.090	2.072	Ecoli
2.754	2.725	2.081	2.023	Staph

After that change the device to read digital reading and add micro controller and liquid crystal display (LCD) to give accurate reading.

Then measure 180 sample (normal and infected) from this measurement we notice the resistance decreases depending on the amount of light intensity.

In the all reading the resistance was decrease in the samples with bacteria more than the sample without bacteria, bacteria cause the solution turbidity, when bacteria grows in the solution the solution turbidity increase the light scattering increase and resistance value decrease except in some sample the value of resistance in normal sample (without bacteria) less than sample with bacteria this abnormal sample are not obtained in suitable environment making them interact and increase the turbidity then the intensity of light was increased and the resistance was decreased.

From this result we must measure the solution turbidity directly after the dialysis process to ensure the validity of the result.

Using linear discriminant analysis to analyze data and achieve classification function to determine the normal and infection range. Using SPSS program to apply the linear discriminant analysis on the sample.

In linear discriminant analysis we are use some independent variable like sex, type of bacteria, solution colour, upper and lower sensor reading the accuracy was low because the sex and type of bacteria are not affected in the classification so we use solution colour, upper and lower reading as independent variables and with/without bacteria as grouped variable.

Group Statistics:

Table 5.3: explain the significant difference between groups by inspecting the group mean and standard deviation.

BACTERIA		Mean	Std. Deviation	Valid N (listwise)	
				Unweighted	Weighted
with bacteria	LOWER	517.23	78.847	90	90.000
	UPPER	580.40	87.285	90	90.000
	SOLUTION	1.52	.502	90	90.000
without bacteria	LOWER	574.06	87.457	90	90.000
	UPPER	626.04	57.550	90	90.000
	SOLUTION	1.52	.502	90	90.000
Total	LOWER	545.64	87.782	180	180.000
	UPPER	603.22	77.192	180	180.000
	SOLUTION	1.52	.501	180	180.000

In discriminant analysis we are trying to predict a group membership, so firstly we examine whether there are any significant differences between groups on each of the independent variables using group means and ANOVA results data. The Group Statistics and Tests of Equality of Group Means tables provide this information. If there are no significant group differences it is not worthwhile proceeding any further with the analysis. A rough idea of variables that may be important can be obtained by inspecting the group means and standard deviations.

Mean differences between MEAN reading and another characteristic (exp SOLUTION reading) depicted in Table5 suggest that these may be good discriminators as the separations are large.

Tests of Equality of Group Means:

Table 5.4:shown the test of equality of group means

	Wilks' Lambda	F	df1	df2	Sig.
LOWER	.895	20.958	1	178	.000
UPPER	.912	17.154	1	178	.000
SOLUTION	1.000	.000	1	178	1.000

Differences between means of bacteria and without bacteria groups for reading with upper and lower producing very high value F's.

At the same table 2 other variable (solution type) provide a weak statistical evidence ;the probability value equal to 1,000 this value is greater than the probability value 0.05this means that it has no effect on the presence of peritonitis infection

The peritonitis infection affected only by bacteria presence (upper and lower sensor reading).

Pooled Within-Groups Matrices:

Table5.5: illustrate the pooled with in groups matrices.

		LOWER	UPPER	SOLUTION
Correlation	LOWER	1.000	-.161	.041
	UPPER	-.161	1.000	.070
	SOLUTION	.041	.070	1.000

The Pooled Within-Group Matrices Table(5.5) also supports use of these IV's as intercorrelations are low, table (5,5) explain the same result that is low correlation between lower, upper reading and solution type, which proving the validity of the selection variable.

Log determinants and Box's M tables:

In discriminant analysis (DA) the basic assumption is that the variance-co-variance matrices are equivalent.

For this assumption to hold, the log determinants should be equal as we see in table (5.6)

When tested by Box's M, we are looking for a non-significant M to show similarity and lack of significant differences. In this case the log determinants appear similar and Box's M is 25.684 with $F = 4.202$ which is significant at $p < .000$ as we see in (Tables 5.7).

Table 5.6: explain log determinant

BACTERIA	Rank	Log Determinant
with bacteria	3	16.153
without bacteria	3	15.637
Pooled within groups	3	16.039

Table 5.7: explain the Box M result

Box's M	25.684
F Approx.	4.202
df1	6
df2	229559.547
Sig.	.000

Eigenvalues:

Table 5.8: explain the Eigen value information about discriminate function

Function	Eigenvalue	% of Variance	Cumulative %	Canonical Correlation
1	.257(a)	100.0	100.0	.452

This provides information on each of the discriminate functions (equations) produced.

The maximum number of discriminant functions produced is the number of groups minus 1.

We are only using two groups here, namely bacteria and without bacteria, so only one function is displayed. The canonical correlation is the multiple correlation between the predictors and the discriminant function. With only one function it provides an index of overall model fit which is interpreted as being the proportion of variance explained (R^2). In our research Table (10) a canonical correlation of .452 suggests the model explains 20.4% of the variation in the grouping variable.

Wilks' Lambda:

Table5.9: explain the wilks lambda test

Test of Function(s)	Wilks' Lambda	Chi-square	Df	Sig.
1	.796	40.335	3	.000

Wilks' lambda indicates the significance of the discriminant function. This table (5.9) indicates a highly significant function ($p < .000$) and provides the proportion of total variability not explained, i.e. it is the converse of the squared canonical correlation. So we have 79.5% unexplained.

Standardized Canonical Discriminant Function Coefficients:

Table5.10: illustrate the importance of each function coefficient

	Function
	1
Lower	0.801
Upper	0.747
Solution	-0.085

The interpretation of the discriminant coefficients (or weights) is like that in multiple regression. Table (5.10) provides an index of the importance of each predictor like the standardized regression coefficients (beta's) did in multiple regression. The sign indicates the direction of the relationship. Lower sensor reading bacteria presence was the strongest predictor for the infection, upper sensor reading also strong in prediction while low solution type was weak in importance as a predictor. These upper and lower sensor reading variables (bacteria presence) with large coefficients stand out as that strongly predict allocation to the infected by peritonitis or not solution type were less successful as predictors as was explained in table(5.8).

Canonical Discriminant Function Coefficients:

Table5.11: illustrate the Canonical Discriminant Function Coefficients

	Function
Lower(X1)	0.010
Upper(X2)	0.010
Solution(X3)	-0.170
(Constant)	-11.086

Unstandardized coefficients

$$D=0.010(\text{lower}) + 0.010(\text{upper}) - 0.170 (\text{solution type}) -11.086$$

$$D=0.010X1 + 0.010X2 - 0.170 X3 -11.086$$

Functions at Group Centroids:

Table5.12: illustrate the unstandardized canonical discriminant functions evaluated at group means.

BACTERIA	Function
	1
with bacteria	-.504
without bacteria	.504

A further way of interpreting discriminant analysis results is to describe each group in terms of its profile, using the group means of the predictor variables. These group means are called centroids. These are displayed in the Group Centroids table (5.12). In this research peritonitis infection (bacteria presence) have a mean of -0.504 while non-peritonitis infection (without bacteria) produce a mean of 0.504.

Cases with value near to a centroid are predicted as belonging to that group.

Table 5.13: Prior Probabilities for Groups

BACTERIA	Prior	Cases Used in Analysis	
		Unweighted	Weighted
with bacteria	.500	90	90.000
without bacteria	.500	90	90.000
Total	1.000	180	180.000

We are notice that the priority of probabilities are equal, have same probability on occurrence.

Classification Results (b,c):

Table5.14: explain the classification result and accuracy

		BACTERIA	Predicted Group Membership		Total
			with bacteria	without bacteria	
Original	Count	with bacteria	63	27	90
		without bacteria	26	64	90
	%	with bacteria	70.0	30.0	100.0
		without bacteria	28.9	71.1	100.0
Cross-validated(a)	Count	with bacteria	61	29	90
		without bacteria	26	64	90
	%	with bacteria	67.8	32.2	100.0
		without bacteria	28.9	71.1	100.0

Finally, there is the classification phase. The classification table, is simply a table in which the rows are the observed categories of the dependent and the columns are the predicted categories. When prediction is perfect all cases will lie on the diagonal.

The classification results Table (5.14) reveal that 70.6% of respondents were classified correctly into ‘bacteria’ or ‘without bacteria’ groups. The peritonitis infection (with bacteria) were classified with slightly better accuracy (70%) than non-peritonitis infection (without bacteria) (71.1%).

The comparison between proto type and turbidimeter:

The classification appear in two figure when using the implemented device and the turbidimeter

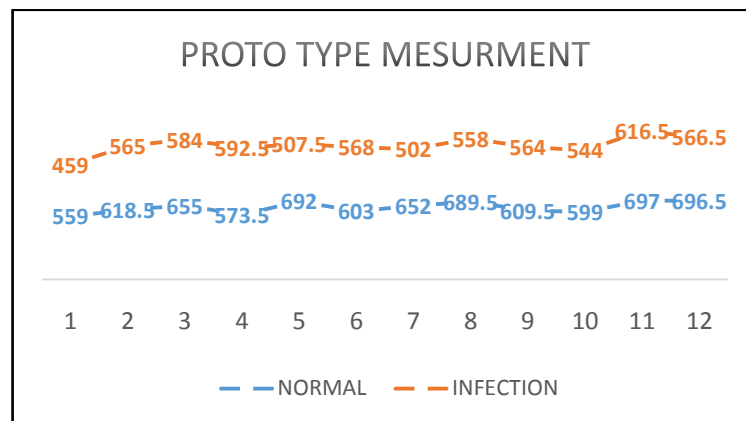


Figure 5.1: explain the 24 evaluation sample was measuring by implemented device

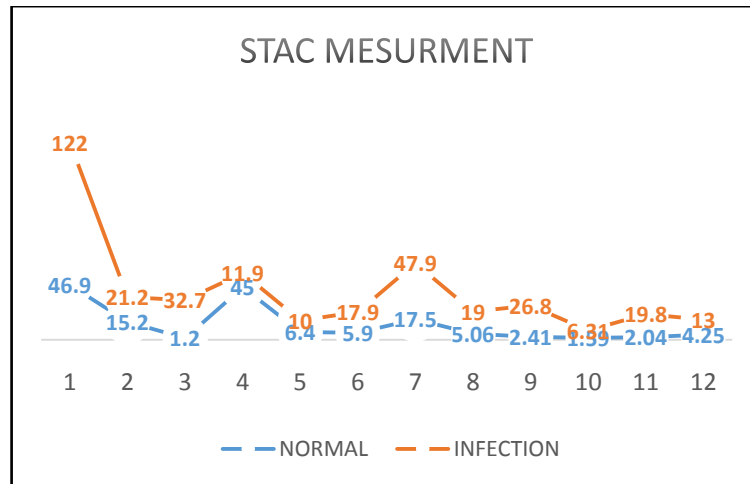


Figure 5.2: illustrate the 24 evaluation sample by tirbidimeter in the National Public Health Laboratory of (STAC).

From the above figures (5.1, 5.2) the same classification and the result of the implemented device was good when comparing with the turbidimeter.

The prototype has satisfied result when comparing with turbidimeter and it is able to discriminate between normal and infected sample.

CHAPTER SIX
CONCLUSION AND RECOMMENDATION

CHAPTER SIX

CONCLUSION AND RECOMMENDATION

6.1 Conclusion:

Peritoneal dialysis removes waste products and excess fluid from the blood through the peritoneum.

A small flexible plastic tube called a peritoneal dialysis catheter is placed in the lower abdomen by a small operation and remains there for the whole duration of dialysis therapy. This space of abdomen or the surface of the skin in general full with bacteria so extreme care and hygiene is needed to avoid the infections

Peritonitis remains an important complication of peritoneal dialysis, peritonitis can lead to peritoneal membrane failure and it is the most common cause of PD system failure and patients discontinuing PD and switching to another treatment.

Proportion to the seriousness of this infection, detected in its early stages was very important

Peritonitis symptoms are abdominal pain, cloudy used dialysate fluid, fever and nausea or diarrhea.

This research focus on cloudy used dialysate symptoms and used it as indicator to the peritonitis infection, where it was detected by light scattering property.

In this research the researcher was design a simple circuit depend on light scattering theory to distinguish the sample (used dialysate) whether or not turbid.

The classification function was produced and the normal sample and peritonitis infection sample were classified with better accuracy (70.6%).

There are some problem that facing us during this research including sample collection because the number of patients are very few, there for we cannot obtaining an infected samples so we sub culturing the samples with standard bacteria and take a long time to get this result.

6.2 Recommendation:

1-To achieve more accurate result add another sensor at another angle like (180°).

2-Increase the number of sample to increase the accurate.

3-Apply the study on another peritoneal dialysis solution extraneal purple one or dianeal with 4.25%glucose concentration are more used after dianeal with 1.5 and 2.5 glucose concentration in Sudan.

4- Using another classification technique suchas neural network or fuzzy logic.

5- Develop the device to read the turbidity level to the solution in the plastic bag (bag of the used dialysate) to facilitate the measurement for patient.

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APPENDICES 1

Peritoneal Dialysis



Solutions for Life . . .

A unique combination of solutions
designed to optimize patient
Peritoneal Dialysis therapy outcomes

Dianeal

Baxter's Premier Peritoneal Dialysis Solution used Globally for over 25 Years by Millions of Patients.

PD4: Na 132, Ca 1.25, Mg 0.25, Cl 95, Lactate 40 mmol/L

PD101: Na 132, Ca 1.62, Mg 0.75, Cl 101.75, Lactate 35 mmol/L

Available in 0.5, 1.5, 2.5 and 4.25% dextrose

Nutrineal^{PD4}

For Treatment of Protein Malnutrition in Peritoneal Dialysis Patients, in a Glucose- Free, Phosphate-Free Exchange.

Na 132, Ca 1.25, Mg 0.25, Cl 105, Lactate 40 mmol/L

Extraneal

Optimum Solution for the Long Dwell in CAPD and APD Patients, using Icodextrin instead of Glucose as the Primary Osmotic Agent.

Na 132, Ca 1.75, Mg 0.25, Cl 96, Lactate 40 mmol/L

Physioneal⁴⁰

A Natural Solution for a Natural Membrane, Providing a Physiologically Balanced

Environment.

Na 132, Ca 1.25, Mg 0.25, Cl 95, Lactate 15mmol/L, Bicarb 25mmol/L

Available in 1.36, 2.27 and 3.86% glucose

Dianeal® PD4, PD101 and Physioneal® 40 Prescribing Information available upon request.

Nutrineal® PD4 (1.1% Amino Acid and Electrolyte Peritoneal Dialysis Solution) and Extraneal® (7.5% Icodextrin) Product

Monographs available upon request.

Peritoneal Dialysis

CAPD – CONTINUOUS AMBULATORY PERITONEAL DIALYSIS

TWIN BAG®

The system of choice for Canadian CAPD patients.
When it comes to your patients, trust TwinBag

- ☐ Simple Design, Successful Therapy
- ☐ Engineered for optimal flush efficiency
- ☐ Protects against touch contamination
- ☐ Allows effective removal of potential contaminants
- ☐ Designed to minimize fibrin blockage
- ☐ Latex free



CATALOGUE NUMBER	CONCENTRATION	FILL VOLUME (mL)	DRAIN BAG VOLUME (mL)	PACK FACTOR
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DIANEAL® - PD4

Na 132, Ca 1.25, Mg 0.25, Cl 95, Lactate 40 mmol/L

JB9415	1.50% Dextrose	1500	2000	6/case
JB9425	2.50% Dextrose	1500	2000	6/case
JB9435	4.25% Dextrose	1500	2000	6/case
JB9416	1.50% Dextrose	2000	2000	6/case
JB9426	2.50% Dextrose	2000	2000	6/case
JB9436	4.25% Dextrose	2000	2000	6/case
JB9418	1.50% Dextrose	2500	3000	4/case
JB9428	2.50% Dextrose	2500	3000	4/case
JB9438	4.25% Dextrose	2500	3000	4/case
JB9413	1.50% Dextrose	3000	3000	4/case
JB9423	2.50% Dextrose	3000	3000	4/case

DIANEAL® - PD101

Na 132, Ca 1.62, Mg 0.75, Cl 101.75, Lactate 35 mmol/L

JB9806	0.50% Dextrose	2000	2000	6/case
JB9816	1.50% Dextrose	2000	2000	6/case
JB9826	2.50% Dextrose	2000	2000	6/case
JB9836	4.25% Dextrose	2000	2000	6/case
JB9818	1.50% Dextrose	2500	3000	4/case
JB9828	2.50% Dextrose	2500	3000	4/case
JB9838	4.25% Dextrose	2500	3000	4/case

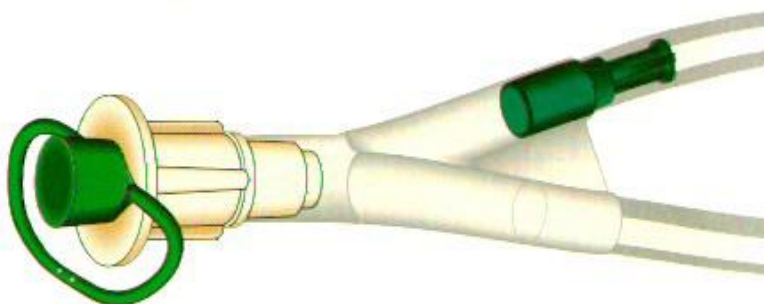
Peritoneal Dialysis

CAPD – CONTINUOUS AMBULATORY PERITONEAL

DIALYSIS

TWIL BAG®

(Continued)



COLOUR CODED CAP

CONFIRMS DEXTROSE CONCENTRATION

White = 0.50% dextrose (Dianeal®)

Yellow = 1.50% dextrose (Dianeal®) and 1.36% glucose (Physioneal®)

Green = 2.50% dextrose (Dianeal®) and 2.27% glucose (Physioneal®)

Red = 4.25% dextrose (Dianeal®) and 3.86% glucose (Physioneal®)

Blue = 1.1% amino acids (Nutrineal®)

Purple = 7.5% Icodextrin (Extraneal®)

CATALOGUE NUMBER	CONCENTR ATION	FILL VOLUME (mL)	DRAIN BAG VOLUME (mL)	PACK FACTOR	
NUTRINEAL®					
Na 132, Ca 1.25, Mg 0.25, Cl 105, Lactate 40 mmol/L					
JB2019		1.1% Amino Acid Solution	2000	2000	6/case
JB2005		1.1% Amino Acid Solution	2500	3000	4/case

EXTRANEAL®**Na 132, Ca 1.75, Mg 0.25, Cl 96, Lactate 40 mmol/L**

JB9912	7.5% Icodextrin Solution	2000	2000	6/case
JB9913	7.5% Icodextrin Solution	2500	3000	4/case

PHYSIONEAL®**Na 132, Ca 1.25, Mg 0.25, Cl 95, Lactate 15, Bicarb 25mmol/L**

JB8249	1.36% Glucose	2000	2500	6/case
JB8251	2.27% Glucose	2000	2500	6/case
JB8254	3.86% Glucose	2000	2500	6/case
JB8250	1.36% Glucose	2500	3000	5/case
JB8252	2.27% Glucose	2500	3000	5/case
JB8255	3.86% Glucose	2500	3000	5/case

Peritoneal Dialysis

CAPD – CONTINUOUS AMBULATORY PERITONEAL DIALYSIS

CATALOGUE NUMBER	DESCRIPTION	PACK FACTOR
------------------	-------------	-------------

Disconnect Y-Sets

5C4366P	Ultra Set Disposable Disconnect Y-Set, 2 Litre, Spike	60/case
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Miscellaneous CAPD Supplies

5C4413	Adapter for Spike	12/case
5C4462	Empty Sterile Bag, 3L, Spike	48/case
XMC4284	Empty Sterile Heater/Drain Bag, 3L, Luer Lock	30/box

CAPD SolutionWarmer

CATALOGUE NUMBER	DESCRIPTION	PACK FACTOR
JBWarmer	CAPD Solution Warmer	1 each

Designed to provide patients with a safe, simple and efficient system for warming TwinBag solutions.

- ☐ Ensures integrity of PD solutions
- ☐ Preset to a safe, comfortable temperature
- ☐ Secondary overheat thermal protector shutoff
- ☐ Lightweight and portable
- ☐ Requires only 20 watts of electricity
- ☐ Made in Canada



APD – AUTOMATED PERITONEAL DIALYSIS

HomeChoicePro™ and HomeChoice™

Automated Peritoneal Dialysis Systems

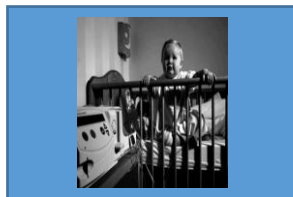
AVAILABLE FOR
PEDIATRIC TO ADULT
PATIENTS

- Pneumatic pumps – no scales!
- No re-calibration necessary after moving the machine
- Improved patient management with ProCard and RenalSoft PD



The low-fill mode option for pediatric and low-fill volume adult patients offers:

- Software that improves drainage of dialysate to avoid over fillings
- Fill volume range from 60– 3000 mL
- Programmable minimum drain time and volume parameters for more closely regulated therapy
- Alarm limits and programmable positive and negative UF alarms ensure proper drainage and increase treatment flexibility



**DEVICES CATALOGUE
NUMBER**

DESCRIPTION

**PACK
FACTOR**

5C4471R

HomeChoice™ Automated PD
System

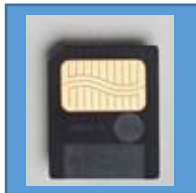
1 each

5C8310P

HomeChoice PRO™ Automated
PD System (110 volt)

1 each

Peritoneal Dialysis Software



- APD therapies are written by the clinician and transferred to the cyclor with the PRO Card

- Window's based software enables increased monitoring of patient adherence, drain function and ultrafiltration

R5C4522

HomeChoice
PRO™ Card

6/case

APD – AUTOMATED PERITONEAL DIALYSIS

APD Luer Lock Solutions

CATALOGUE NUMBER	CONCENTRATION	FILL VOLUME (mL)	PACK FACTOR
---------------------	---------------	---------------------	-------------

DIANEAL® - PD4

Na 132, Ca 1.25, Mg 0.25, Cl 95, Lactate 40 mmol/L

JB4769L	1.50% Dextrose	3000	4/case
JB4770L	2.50% Dextrose	3000	4/case
JB4771L	4.25% Dextrose	3000	4/case
JB9719L	1.50% Dextrose	5000	2/case
JB9729L	2.50% Dextrose	5000	2/case
JB9749L	4.25% Dextrose	5000	2/case

DIANEAL® - PD101

Na 132, Ca 1.62, Mg 0.75, Cl 101.75, Lactate 35 mmol/L

JB4821L	0.50% Dextrose	2000	6/case
JB5618L	1.50% Dextrose	2500	5/case
JB5658L	2.50% Dextrose	2500	5/case
JB5619L	1.50% Dextrose	5000	2/case
JB5659L	2.50% Dextrose	5000	2/case
JB5669L	4.25% Dextrose	5000	2/case

NUTRINEAL®

Na 132, Ca 1.25, Mg 0.25, Cl 105, Lactate 40 mmol/L

B2006LP	1.1% Amino Acid Solution	2500	5/case
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EXTRANEAL®

Na 132, Ca 1.75, Mg 0.25, Cl 96, Lactate 40 mmol/L

JB9923LP	7.5% Icodextrin Solution	2500	5/case
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PHYSIONEAL® 40

Na 132, Ca 1.25, Mg 0.25, Cl 95, Lactate 15, Bicarb 25 mmol/L

JB8291	1.36% Glucose	2500	5/case
JB8290	2.27% Glucose	2500	5/case
JB8289	3.86% Glucose	2500	5/case

PHYSIONEAL® 40 CLEARFLEX

Na 132, Ca 1.25, Mg 0.25, Cl 95, Lactate 15, Bicarb 25 mmol/L

CJPE8280	1.36% Glucose	5000	2/case
CJPE8281	2.27% Glucose	5000	2/case
CJPE8282	3.86% Glucose	5000	2/case

APD – AUTOMATED PERITONEAL DIALYSIS

APD DISPOSABLE LUER SETS

L5C4531	3-Prong Cyclor Set with Cassette	30/case
R5C4479C	4-Prong Cyclor Set with Cassette	30/case
R5C4478	8-Prong Cyclor Set with Cassette	30/case
R5C4427	5-Prong Manifold Set	30/case
N5C8305C	Low Recirculation Volume APD Set	30/case



Low Recirculation Volume APD Set has in-line medication port, LuerLock to bag connectors, a shrouded patient connector which covers all transfer set threads, and a smaller internal diameter and shorter patient line length which reduces patient line recirculation volume to 17mL for a more efficient therapy.

APD EXTENSION LINE

5C4480C	12 Foot Patient Extension Line, Easy Lock™ Connector (3.6M)	30/case
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APD DRAIN SUPPLIES

XMC4284	Empty Sterile Heater\Drain Bag, 3L, Luer Lock	30/box
5C4462	Empty Sterile Bag, 3L, Spike	48/case
5C4476	Effluent Sample Bag, 150ml, Luer	6/case
5C4145P	Cyclor Drainage Bag Set (2 x 15L per pack), Spike	15 pk/case
5C4512	APD Drain Manifold (Connects 2 15 Litre drain bags), Spike	30/case
5C4464P	12 Foot Drain Line Extension Set (3.6M), Spike	30/case

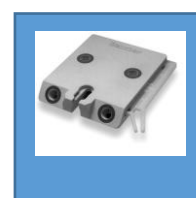
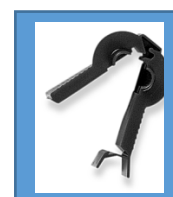
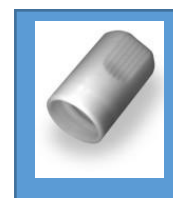


APD CARRYING CASES

5C4406	HomeChoice: Soft-sided Carrying Case	1 each
5C8346	HomeChoice: Shipping Case with wheels	1 each
5C4971	Quiet Coil	1 each



CATALOGUE NUMBER	DESCRIPTION	PACK FACTOR
Transfer Sets		
Disconnect System		
5C4483	MiniCap Extended Life Transfer Set with Twist Clamp (10cm)*	6/case
5C4482	MiniCap Extended Life Transfer Set with Twist Clamp (15cm)*	6/case
R5C4484	MiniCap Extended Life Transfer Set with Twist Clamp (22cm)*	6/case
5C4449	MiniCap Extended Life Transfer Set with Roller Clamp (15cm)*	6/case
Non-Disconnect System		
5C4160	System III Transfer Set with Spike Connector (120cm)*	12/case
Extended Life Transfer Set Wear – 6 months		
Transfer Set Adapters		
5C4136	Luer-Lock to Spike Adapter Set	12/case
5C4137	Spike to Luer-Lock Adapter Set	12/case
Catheter Supplies		
5C4129	Locking Titanium Adapter (2 pieces)	5/case
5C4169	Locking Cap for 5C4129 Titanium Adapter	25/case
PC4171	Catheter Clamp	12/case
5C4319	Immobile™ catheter and transfer set stabilizing device	30/case
5C4320	Immobile A/C, Catheter stabilizer	30/case
5C4381	Immobile™ catheter stabilizing device	30/case
Disconnect Caps with Pre-filled Povidone-Iodine Solution		
5C4466P	MiniCap Disconnect Cap (English labeling only)	60/case
RPC4466	MiniCap Disconnect Cap	60/case
SPC4486	OptiCap Disconnect Cap	30/case
Clamps		
5C4527	Outlet Port Clamp, Short-Nosed, Blue	12/case
5C4957	UltraClamp, Red (Not for	12/case



EZ-Aide®

use as outlet port clamp)

5C4505

Assist Device for CAPD
or APD patients

1 each

Bolded codes are preferred products

APPENDICES 2

Features

- High-performance, Low-power Atmel® AVR® 8-bit Microcontroller
- Advanced RISC Architecture
 - 131 Powerful Instructions – Most Single-clock Cycle Execution
 - 32 x 8 General Purpose Working Registers
 - Fully Static Operation
 - Up to 16 MIPS Throughput at 16 MHz
 - On-chip 2-cycle Multiplier
- High Endurance Non-volatile Memory segments
 - 16 Kbytes of In-System Self-programmable Flash program memory
 - 512 Bytes EEPROM
 - 1 Kbyte Internal SRAM
 - Write/Erase Cycles: 10,000 Flash/100,000 EEPROM
 - Data retention: 20 years at 85°C/100 years at 25°C⁽¹⁾
 - Optional Boot Code Section with Independent Lock Bits
- In-System Programming by On-chip Boot Program
- True Read-While-Write Operation
 - Programming Lock for Software Security
- JTAG (IEEE std. 1149.1 Compliant) Interface
 - Boundary-scan Capabilities According to the JTAG Standard
 - Extensive On-chip Debug Support
 - Programming of Flash, EEPROM, Fuses, and Lock Bits through the JTAG Interface
- Peripheral Features
 - Two 8-bit Timer/Counters with Separate Prescalers and Compare Modes
 - One 16-bit Timer/Counter with Separate Prescaler, Compare Mode, and Capture

**8-bit
Microcontroller
With 16K Bytes
In-System
Programmable
Flash
ATmega16
ATmega16L**

Mode

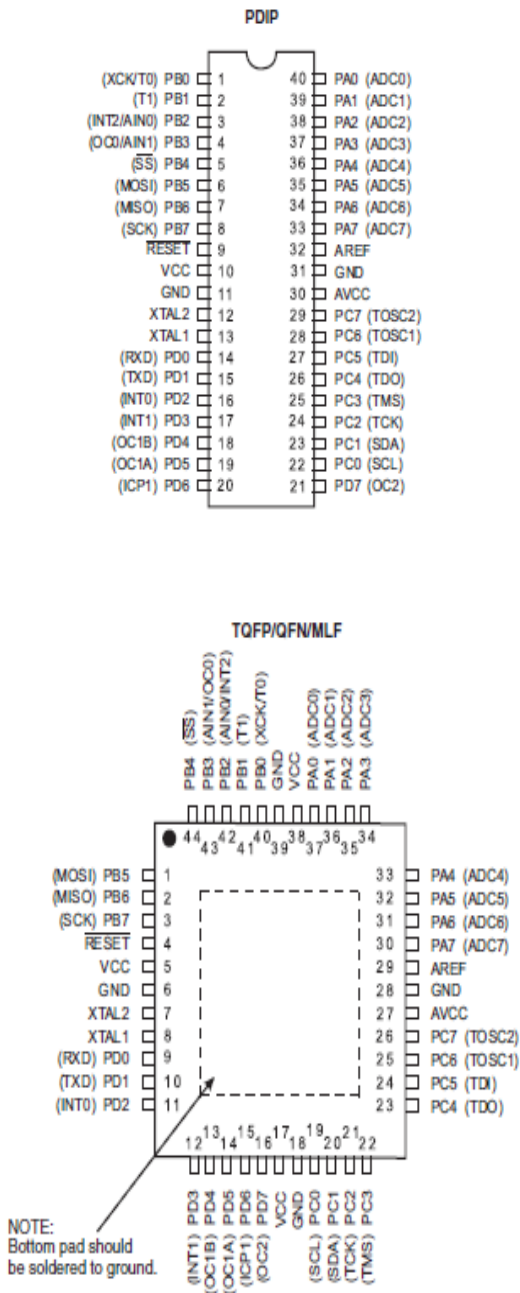
- Real Time Counter with Separate Oscillator
- Four PWM Channels
- 8-channel, 10-bit ADC
- 8 Single-ended Channels
- 7 Differential Channels in TQFP Package Only
- 2 Differential Channels with Programmable Gain at 1x, 10x, or 200x
- Byte-oriented Two-wire Serial Interface
- Programmable Serial USART
- Master/Slave SPI Serial Interface
- Programmable Watchdog Timer with Separate On-chip Oscillator
- On-chip Analog Comparator
- Special Microcontroller Features
 - Power-on Reset and Programmable Brown-out Detection
 - Internal Calibrated RC Oscillator
 - External and Internal Interrupt Sources
 - Six Sleep Modes: Idle, ADC Noise Reduction, Power-save, Power-down, Standby and Extended Standby
- I/O and Packages
 - 32 Programmable I/O Lines
 - 40-pin PDIP, 44-lead TQFP, and 44-pad QFN/MLF
- Operating Voltages
 - 2.7V - 5.5V for ATmega16L
 - 4.5V - 5.5V for ATmega16
- Speed Grades
 - 0 - 8 MHz for ATmega16L
 - 0 - 16 MHz for ATmega16
- Power Consumption @ 1 MHz, 3V, and 25°C for ATmega16L
 - Active: 1.1 mA
 - Idle Mode: 0.35 mA
 - Power-down Mode: < 1 µA

Rev. 2466T-AVR-07/1

ATmega16(L)

Pin Configurations

Figure 1. Pinout ATmega16



Disclaimer

Typical values contained in this datasheet are based on simulations and characterization of other AVR microcontrollers manufactured on the same process technology. Min and Max values will be available after the device is characterized.

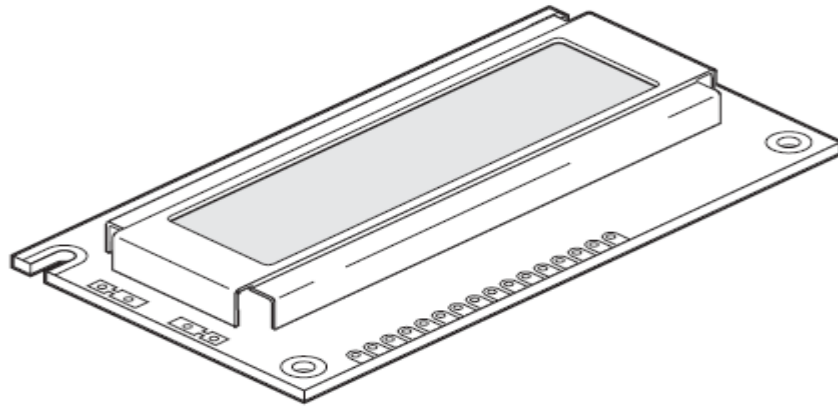
APPENDICES 3

ALPHANUMERIC LCD DISPLAY (16 x 2)

Order Code

LED008 16 x 2 Alphanumeric Display

FRM010 Serial LCD Firmware (optional)



Contents

1 x 16x2 Alphanumeric Display

1 x data booklet

Introduction

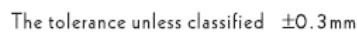
Alphanumeric displays are used in a wide range of applications, including palmtop computers, word processors, photocopiers, point of sale terminals, medical instruments, cellular phones, etc. The 16 x 2 intelligent alphanumeric dot matrix display is capable of displaying 224 different characters and symbols. A full list of the characters and symbols is printed on pages 7/8 (note these symbols can vary between brand of LCD used). This booklet provides all the technical specifications for connecting the unit, which requires a single power supply (+5V).

Further Information

Available as an optional extra is the Serial LCD Firmware, which allows serial control of the display. This option provides much easier connection and use of the LCD module. The firmware enables microcontrollers (and microcontroller based systems such as the PICAXE) to visually output user instructions or readings onto

An example PICAXE instruction to print the text ‘Hello’ using the **serout** command is as follows:

Outline Dimension and Block Diagram



Pin no.	Symbol	Function
1	V _{SS}	Power supply (GND)
2	V _{DD}	Power supply (+5V)
3	V ₀	Contrast Adjust
4	RS	Register select signal
5	R/W	Data read /write
6	E	Enable signal
7	DB0	Data bus line
8	DB1	Data bus line
9	DB2	Data bus line
10	DB3	Data bus line
11	DB4	Data bus line
12	DB5	Data bus line
13	DB6	Data bus line
14	DB7	Data bus line
15	A	Power supply for LED B/L (+)
16	K	Power supply for LED B/L (—)

ABSOLUTE MAXIMUM RATING					
Item	Symbol	Conditions	Min.	Max.	Unit
Power Supply Voltage	$V_{DD}-V_{SS}$	—	0	7	V
LCD Driving Supply Voltage	$V_{DD}-V_{EE}$	—	0	13	V
Input Voltage	V_{in}	—	-0.3	$V_{DD}+0.3$	V
Operating Temperature	T_{opr}	Nor.	0	50	°C
Storage Temperature	T_{stg}	Nor.	-20	+70	°C

ELECTRICAL CHARACTERISTICS ($V_{dd} = +5V, T_a = 25^{\circ}C$)						
Item	Symbol	Conditions	Min.	Typ.	Max.	Unit
Logic Supply Voltage	V_{dd}	—	4.5	5	5.5	V
"H" Input Voltage	V_{IH}	—	2.2	—	—	V
"L" Input Voltage	V_{IL}	—	—	—	0.6	V
"H" Output Voltage	V_{OH}	—	2.4	—	—	V
"L" Output Voltage	V_{OL}	—	—	—	0.4	V
Supply Current	I_{dd}	—	2	—	—	mA
LCD Driving Voltage	V_{CD}	$V_{DD}-V_O$	4.3	—	4.8	V

V_{DD} = 5V±5%
V_{SS} = 0V

Timing Chart

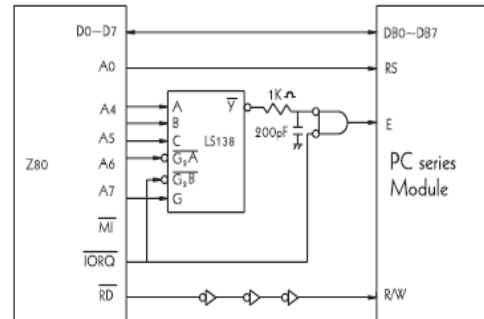
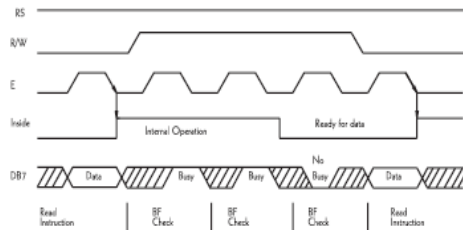
The timing diagram illustrates the following parameters:

- t_{SU}** : Setup time for RS and R/W signals before E transitions high.
- t_H** : Hold time for RS and R/W signals after E transitions high.
- t_{PWR}** : Power-up delay from the start of the power supply to the first valid data output.
- t_W** : Wait time after the last data output before RS and R/W signals can change.
- t_D** : Data delay from the rising edge of E to the data output.
- t_{DQ}** : Data output delay from the rising edge of E to the data output.
- Wild Data**: A period where the data output is not guaranteed to be valid during the power-up delay.

(Read Data from MODULE to MPU)

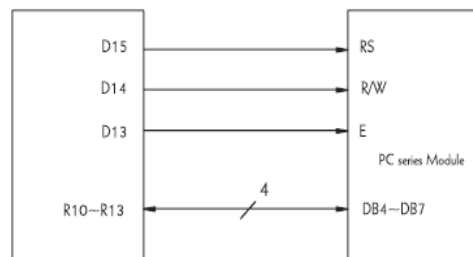
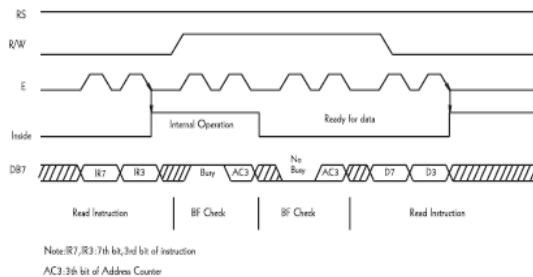
Interface with MPU

◆ Example of Interface with 8-bit MPU (Z80)



◆ Example of interface with 4-bit MPU

Interface with 4-bit MPU can be made through I/O port of 4-bit MPU. If there are enough I/O ports, data can be transferred by 8-bit, however, if there are not data transfer can be done by 4-bit in twice (select interface is 4-bit long), and timing sequence will be complicated in this case. Please take into account



Features

- (1) Interface with 8-bit or 4-bit MPU is available.
- (2) 192 kind of alphabets, numerals, symbols and special characters can be displayed by built-in character generator (ROM).
- (3) Other preferred characters can be displayed by character generator (RAM).
- (4) Various functions of instruction are available by programming.
 - Clear display • Cursor at home • On / off cursor
 - Blink character • Shift display • Shift cursor
 - Read / write display data.....etc.
- (5) Compact and light weight design which can be easily assembled in devices.
- (6) Single power supply +5V drive (except for extended temp. type).
- (7) Low power consumption.

*Interface between data bus line and 4-bit or 8-bit MPU is available.

Data transfer are made in twice in case of 4-bit MPU, and once in case of 8-bit MPU.

◆ If interface data is 4-bit long

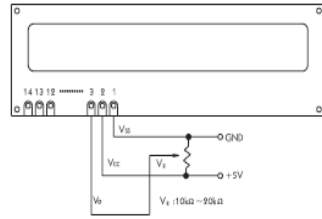
Data transfer are made through 4 bus lines from DB4 to DB7. (while the rest of 4 bus lines from DB0 to DB3 are not used.) Data transfer with MPU are completed when 4-bit data are transferred in twice. (first upper 4-bit data. then lower 4-bit data.)

◆ If interface data is 8-bit long

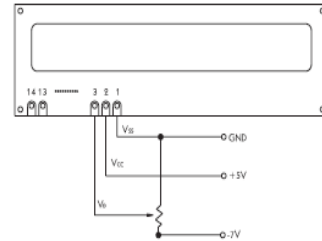
Data transfer are made through all of 8 bus lines from DB0 to DB7.

Example of Power Supply

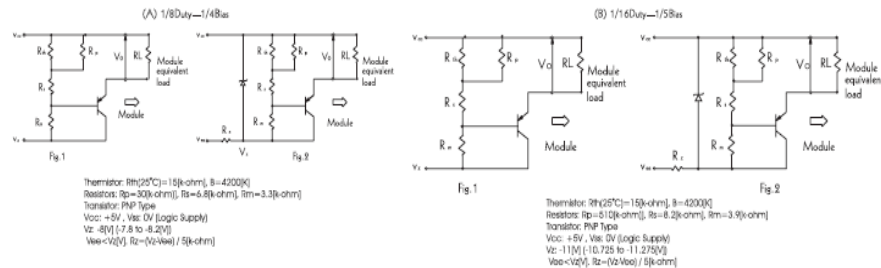
◆ Normal Temperature Type



◆ Extended Temperature Type



◆ Examples of Temperature Compensation Circuits for Extended Temp Type. (Only for reference)



Instructions

Instruction	Code										Description	Executed Time(max.)
	RS	R/W	DB7	DB6	DB5	DB4	DB3	DB2	DB1	DB0		
Clear Display	0	0	0	0	0	0	0	0	0	1	Clears all display and returns the cursor to the home position (Address 0)	1.64mS
Cursor At Home	0	0	0	0	0	0	0	0	1	*	Returns the cursor to the home position (Address 0). Also returns the display being shifted to the original position. DD RAM contents remain unchanged.	1.64mS
Entry Mode Set	0	0	0	0	0	0	0	1	1/D	S	Sets the cursor move direction and specifies or not to shift the display. These operations are performed during data write and read.	40μS
Display On / Off Control	0	0	0	0	0	0	1	D	C	B	Sets ON / OFF of all display (D), cursor NO / OFF (C), and blink of cursor position character (B).	40μS
Cursor / Display Shift	0	0	0	0	0	1	S/C	R/L	*	*	Moves the cursor and shifts the display without changing DD RAM contents.	40μS
Function Set	0	0	0	0	1	DL	N	F	*	*	Sets interface data length (DL) number of display lines (L) and character font (F)	40μS
CG RAM Address Set	0	0	0	1	ACG						Sets the CG RAM address. CG RAM data is sent and received after this setting.	40μS
DD RAM Address Set	0	0	1	ADD						Sets the DD RAM address. DD RAM data is sent and received after this setting.	40μS	
Busy Flag / Address Read	0	1	BF	AC						Reads Busy flag (BF) indicating internal operation is being performed and reads address counter counts.	0μS	
CG RAM / DD RAM Data Write	1	0	WRITE DATA						Writes data into DD RAM or CG RAM.	40μS		
CG RAM / DD RAM Data Read	1	1	READ DATA						Reads data from DD RAM or CG RAM.	40μS		
Code											Description	Executed Time (max)
I/D = 1:Increment I/D = 0:Decrement S = 1:With display shift S/C = 0:cursor movement R/L = 1: Shift to the right R/L = 0: Shift to the left DL = 1: 8-bit			DL = 0:4-bit N = 1:2lines N = 0:1line F = 1:5×10dots F = 0.5×7 dots BF = 1:Internal operation is being performed BF = 0:Instruction acceptable								DD RAM:Display Data RAM CG RAM:Character Generator RAM ACG:CG RAM Address ADD:DD RAM Address Corresponds to cursor address. AC:Address Counter, used for both DD RAM and CG RAM *:Invalid	fcp or fosc = 250KHz However, when frequency changes, execution time also changes Example if fcp or fosc is 270KHz, 70μS×250/270 = 37μS

Power Supply Reset

The internal reset circuit will be operated properly when the following power supply conditions are satisfied. If it is not operated properly, please perform initial setting along with the instruction.

Item	Symbol	Measuring Condition	Standard Value			Unit
			Min.	Typ.	Max.	
Power Supply RISE Time	tree	—	0.1	—	10	mS
Power Supply CFF Time	toff	—	1	—	—	mS

Reset function

◆ Initialization Made by Internal Reset Circuit

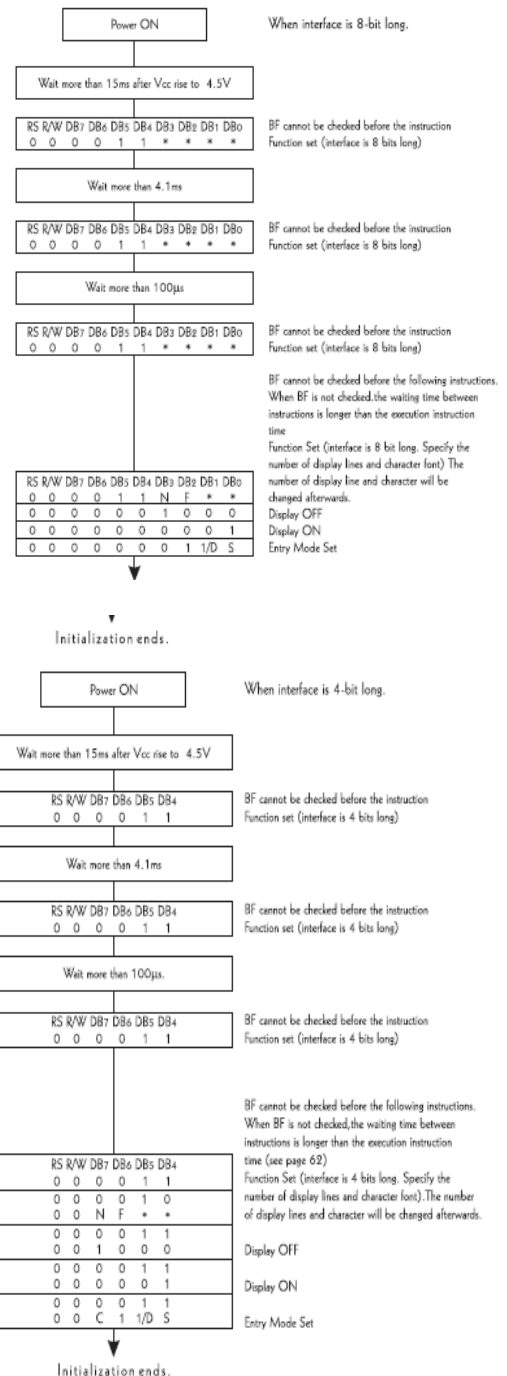
HD44780 automatically initializes (resets) when power is supplied (builtin internal reset circuit). The following instructions are executed in initialization. The busy flag (BF) is kept in busy state until initialization ends. (BF=1) The busy state is 10 ms after Vdd reaches to 4.5V.

- (1) Display clear
- (2) Function set
 - DL= 1:8 bit long interface data
 - DL= 0:4 bit F= 0:5 x 7 dots character font
 - N= 1:2 lines
 - N= 0:1 line
- (3) Display ON / OFF control
 - D= 0:Display OFF C= 0:Cursor OFF
 - B= 0:Blink OFF
- (4) Entry mode set
 - 1 / D= 1:+1(increment) S= 0:No shift

Note:When conditions stated in power supply conditions using internal reset circuit are not satisfied.The internal reset circuit will not operate properly and initialization will not be performed. Please make initialization using MPU along with instruction.

◆ Initialization along with instruction

If power supply conditions are not satisfied, which for proper operation of internal rest circuit, it is required to make initialization along with instruction. Please make following procedures.



Standard Character Pattern (Powertip Module)

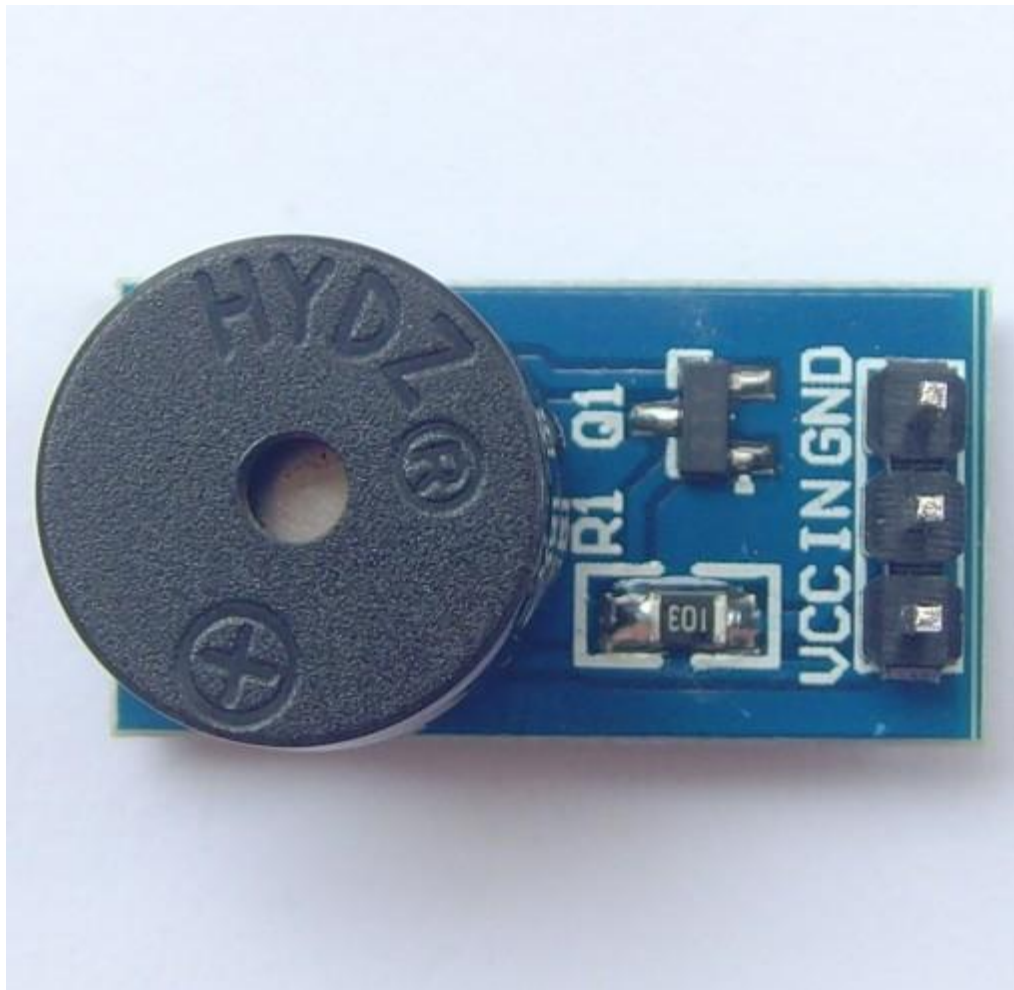
		Higher 4-bit (D4 to Character Code (Hexadecimal))																
		0	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F	
Lower 4-bit (D0 to D3) c_{ij} of Character Code (Hexadecimal)	0	CG RAM (1)	±		0	0	P	'	P	9	é	á	'		r	p	p	v
	1	CG RAM (2)	≡	!	1	A	a	4	0	2	í	'	,	+	y	v		
	2	CG RAM (3)	"	"	2	B	R	b	r	é	F	6	*	o	8	8	Q	
	3	CG RAM (4)	#	#	3	C	S	c	s	á	ó	ó	'	P	W	e	w	
	4	CG RAM (5)	\$	\$	4	D	T	t	t	á	ó	ó	'	4	r	z	o	
	5	CG RAM (6)	%	%	5	E	U	e	u	á	ó	ó	'	5	t	á	n	W
	6	CG RAM (7)	&	&	6	F	V	v	v	á	ó	ó	'	6	u	á	o	W
	7	CG RAM (8)	'	'	7	G	W	w	w	ó	ó	ó	'	7	x	÷	^	W
8	CG RAM (1)	(	(	8	H	X	x	x	é	ó	ó	'	÷	÷	÷	K	W	
9	CG RAM (2)	)	)	9	I	Y	y	y	é	ó	ó	'	¿	¿	¿	^	4	
A	CG RAM (3)	*	*	*	J	Z	z	z	é	ó	ó	'	¿	¿	¿	^	F	
B	CG RAM (4)	+	+	+	K	T	t	t	ó	ó	ó	'	¿	¿	¿	^	W	
C	CG RAM (5)	=	=	=	L	\	\	\	ó	ó	ó	'	¿	¿	¿	^	W	
D	CG RAM (6)	~	~	~	M	]	]n	]n	ó	ó	ó	'	¿	¿	¿	^	W	
E	CG RAM (7)	~	~	~	N	^	^	^	ó	ó	ó	'	¿	¿	¿	^	W	
F	CG RAM (8)	~	~	~	O	_	_	_	ó	ó	ó	'	¿	¿	¿	^	W	

Standard Character Pattern (Elec&Eltek Module)

Upper(4bit) Lower(4bit)		LLLL	LLHL	LLHH	LHLL	LHLH	LHHH	HLLL	HLLH	HLHL	HLHH	HHLL	HHLH	HHHL	HHHH
LLLL	CG RAM (1)														
LLHH	(2)														
LLHL	(3)														
LLHH	(4)														
LHLL	(5)														
LHLH	(6)														
LHHL	(7)														
LHHH	(8)														
HLLL	(1)														
HLLH	(2)														
HLHL	(3)														
HLHH	(4)														
HHLL	(5)														
HHLH	(6)														
HHHL	(7)														
HHHH	(8)														

APPENDICES 4

5V Buzzer Module



General Description:

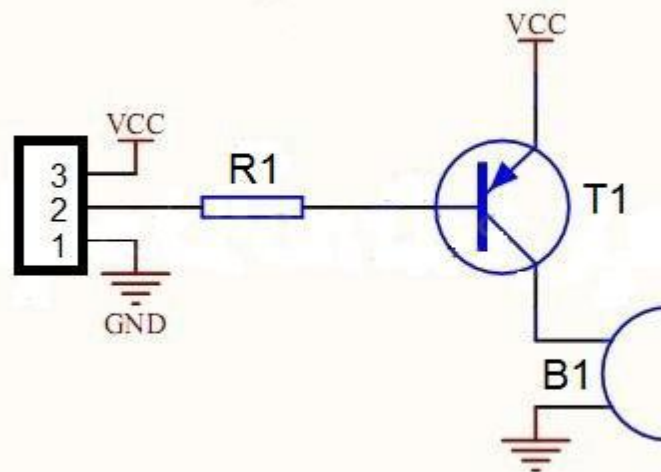
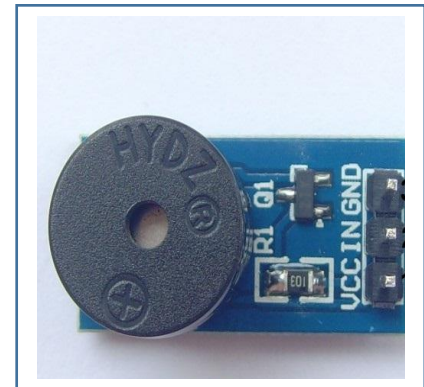
A buzzer or beeper is an audio signaling device, which may be mechanical, electromechanical, or piezoelectric. Typical uses of buzzers and beepers include alarm devices, timers and confirmation of user input such as a mouse click or keystroke. Buzzer is an integrated structure of electronic transducers, DC power supply, widely used in computers, printers, copiers, alarms, electronic toys, automotive electronic equipment, telephones, timers and other electronic products for sound devices. Active buzzer 5V Rated power can be directly connected to a continuous sound, this section dedicated sensor expansion module and the board in combination, can complete a simple circuit design, to "plug and play."

Specifications:

- On-board passive buzzer
- On-board 8550 triode drive
- Can control with single-chip microcontroller IO directly
- Working voltage: 5V
- Board size: 22 (mm) x12 (mm)

Pin Configuration:

1. VCC
2. Input
3. Ground

Schematic Diagram:

How to test:

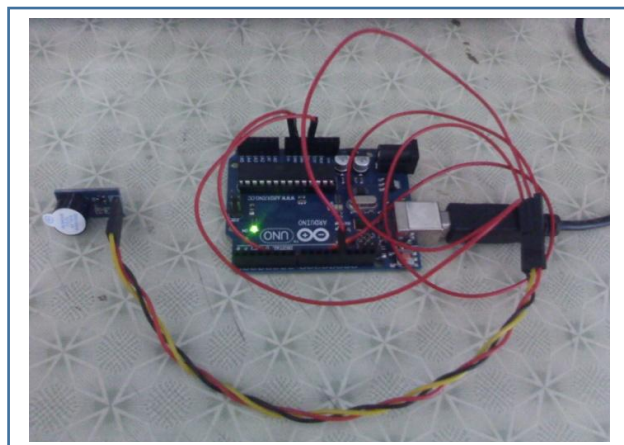
1. Connect your Arduino microcontroller to the computer.
2. Connect the VCC pin of your module to the 5V pin of your Arduino.
3. Connect the GND pin of your module to the GND pin of your Arduino.
4. Connect the Input pin of your module to the pin 13 of your Arduino.
5. Enter this program to your Arduino Integrated Development Environment (IDE):

```
int buzzer = 13;  
void setup()  
{  
  pinMode(buzzer, OUTPUT);  
}  
void loop()  
{  
  digitalWrite(buzzer, HIGH);  
  delay(1000);  
  digitalWrite(buzzer, LOW);  
  delay(1000);  
}
```

6. Lastly, click the Upload Button.

Testing Results:

The sample sketch above is a blink which is also applicable for LEDs. The output is the turning on and off of the buzzer every other second. The picture below shows the setup of your module and Arduino:



APPENDICES 5

شهادة التحليل

رقم الشهادة : ٢٠١٦/١٥٠١-١٤٨٧
تاريخ إصدار الشهادة : ٢٠١٧/١/٢
اسم صاحب العينة : باحث/ اسراء طه علي
مصدر العينة/الجهة الراسلة: جامعة السودان للعلوم والتكنولوجيا/ قسم الهندسة الطبية الحيوية
نوع العينات : محلول الغسيل، البيرتوني المستخدم
التحاليل المطلوبة : تحديد درجة العكورة
وصف العبوة : أخذت العينات في عبوات من البلاستيك

رقم العينة	لون المحلول، حسب مائكر بالعبوة	درجة العكورة (NTU)
1 WoB	Green solution	46.9
2 WoB	Green solution	45
3 WoB	Green solution	5.9
4 WoB	Green solution	2.4
5 WoB	Green solution	1.59
6 WoB	Green solution	15.2
7 WoB	Yellow solution	1.2
8 WoB	Yellow solution	6.4
9 WoB	Yellow solution	17.2
10 WoB	Yellow solution	5.06
11 WoB	Yellow solution	2.04
12 WoB	Yellow solution	4.25
13 WB	Green solution	122
14 WB	Green solution	11.9
15 WB	Green solution	17.5
16 WB	Green solution	26.8
17 WB	Green solution	6.31
18 WB	Yellow solution	21.2
19 WB	Yellow solution	32.7
20 WB	Yellow solution	10.0
21 WB	Yellow solution	47.9
22 WB	Yellow solution	19
23 WB	Yellow solution	19.8
24 WB	Yellow solution	13

WoB = without Bacteria
WB = with Bacteria


باحث/ هانية أحمد الهادي
رئيس قسم المياه
المعامل الكيميائية القومية



لحوظة: هذه الشهادة تنطبق على العينات المرسلة فقط وقد لا تنطبق على اي عينات اجري مشابهة.

شهادة التحليل

رقم الشهادة : ٢٧٦ ، ٢٧٧ ، ٢٩٣ ، ٣٠٢ ، ٣٠٣ ، ٣٠٨ ، ٣٠٩ ، ٣١٠ ، ٣١٣ ، ٣٤٨ ، ٣٤٩ ، ٣٥٠ ، ٣٥١ ، ٣٥٢ ، ٣٥٣

٢٠١٦ / ٢٦٨ ، ٢٦٧

تاريخ اصدار الشهادة : ٢٠١٦/٣/٢٨

مصدر العينة/ الجهة الراثة : جامعة السودان للعلوم والتكنولوجيا / قسم الهندسة الطبية الحيوية

صاحب العينة : اسراء طه على

تاريخ الاستلام : ٢٠١٦/٣/٦

تاريخ الارسال : ٢٠١٦ / ٢ / ٢٨

اسم العينات : عينات مياه

الغرض من التحليل : تحديد درجة العكورة

رقم العينة	اسم العينة	درجة العكورة NTU
	Fresh dialysate	
1-	Yellow solution A	0.2
2-	Green Solution B	1.2
3-	Purple solution C	2.3
	Used dialysate (Drain)	
4-	Yellow solution	2.89
5-	Yellow solution	2.5
6-	Yellow solution	3.09
7-	Yellow solution	3.58
8-	Yellow Solution	1.7
9-	Green solution	4.90
10-	Green solution	1.88
11-	Green solution	2.6
12-	Green solution	6.16
13-	Purple solution	13.9
	Peritonits In fection	
14-	Yellow solution (6 day)	4.8
15-	Yellow solution (11 day)	4.56
16-	Yellow Solution (18 day)	1.01
17-	Yellow solution	14.9

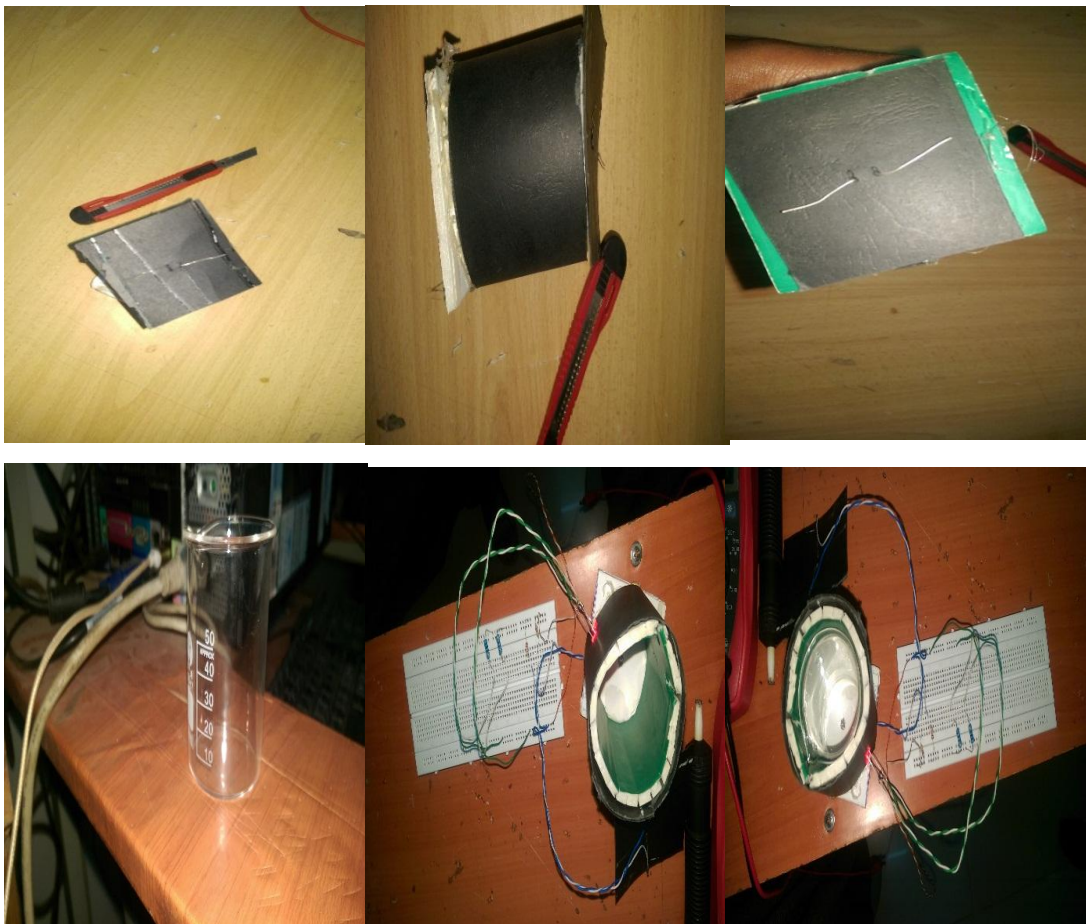
باحث/ هادي احمد الهادي
رئيس قسم المياه
المعامل الكيماوية القومية

APPENDICES 6

Picture 1 (A, B, C) explain the fresh dialysate in the bag in order its Yellow, Green,Red :



Picture 2 (A, B, C, D, E, F, G, H) explain the analog device design level:





Picture (A,B) explain the samples container:



Picture 2 (A, B, C, D,E) explain the device design with microcontroller and LCD:

