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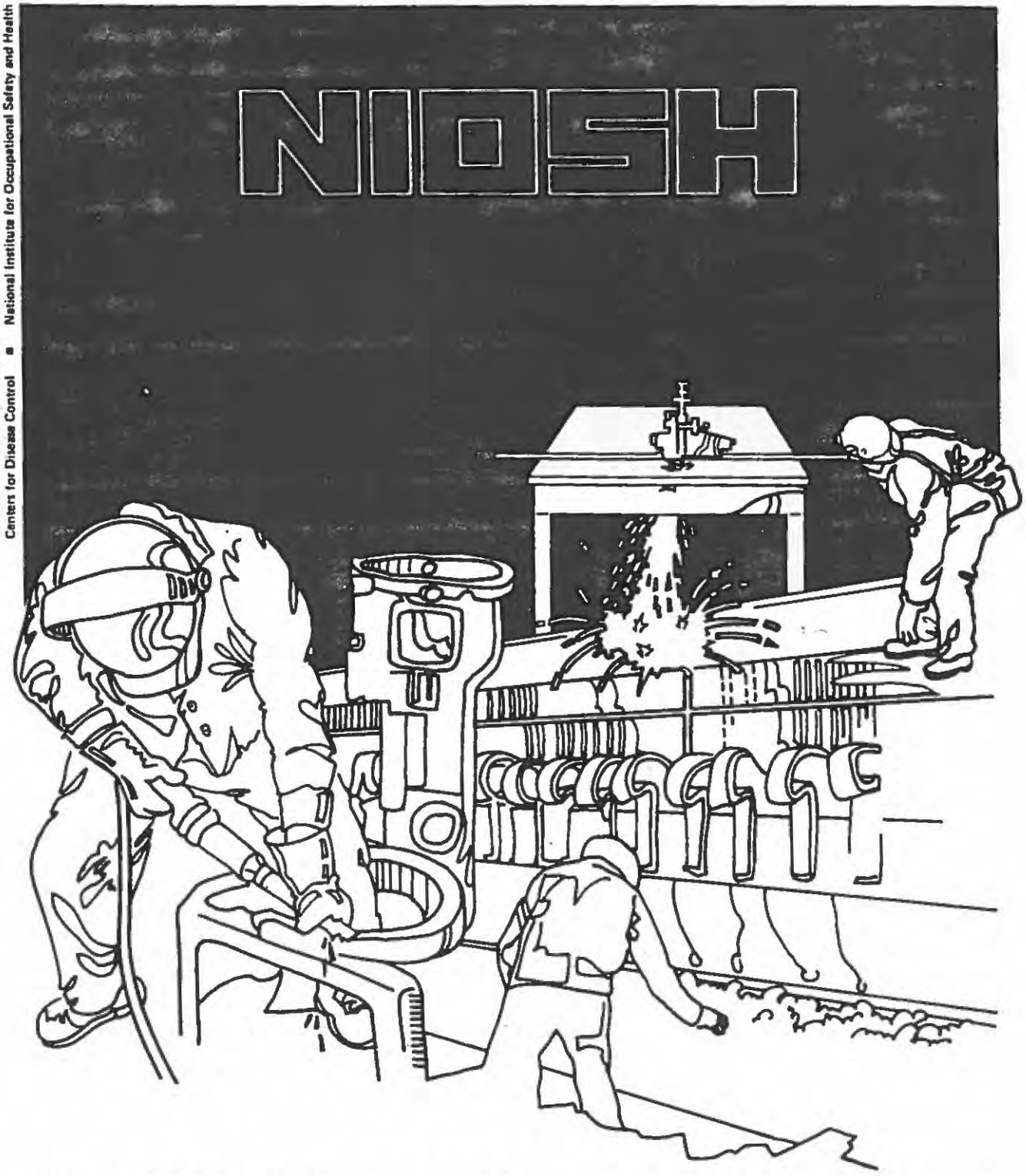

# Health Hazard Evaluation Report

HETA 82-387-1392
EXXON CORPORATION
BATON ROUGE, LOUISIANA

## PREFACE

The Hazard Evaluations and Technical Assistance Branch of NIOSH conducts field investigations of possible health hazards in the workplace. These investigations are conducted under the authority of Section 20(a)(6) of the Occupational Safety and Health Act of 1970, 29 U.S.C. 669(a)(6) which authorizes the Secretary of Health and Human Services, following a written request from any employer or authorized representative of employees, to determine whether any substance normally found in the place of employment has potentially toxic effects in such concentrations as used or found.

The Hazard Evaluations and Technical Assistance Branch also provides, upon request, medical, nursing, and industrial hygiene technical and consultative assistance (TA) to Federal, state, and local agencies; labor; industry and other groups or individuals to control occupational health hazards and to prevent related trauma and disease.

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## I. SUMMARY

In September 1982, the National Institute for Occupational Safety and Health received a request to conduct a Health Hazard Evaluation of male workers in the wastewater treatment plant of the Exxon Oil Refinery at Baton Rouge, Louisiana.

The men in the refinery's wastewater treatment plant had previously expressed concern about an excessive rate of spontaneous abortions among their wives since the plant opened in 1976. A questionnaire study was performed by an outside consulting group at the request of the company which showed twice the rate of fetal loss in the period after employment in the plant as compared with the period before employment. Because of questions regarding the interpretation of that study and continuing concern about reproductive risk among the wastewater treatment plant workers, NIOSH conducted a cross-sectional evaluation of sperm concentration and sperm morphology (abnormal head shapes) of these workers in December 1982. The evaluation included two unexposed comparison groups: workers in other portions of the refinery and administrative personnel who did not work in the refinery itself. The unexposed men were similar with respect to sperm morphology and concentration and were combined to form a single comparison group of 73 persons. After the data were adjusted for abstinence period, the mean sperm concentration of the unexposed group did not differ significantly from that of the 42 exposed men (80.8 million/$cm^3$ versus 66.9 million/$cm^3$ respectively, $P_{(1)}$= 0.16). The two groups also had a similar proportion of sperm with abnormal morphology (48.8% versus 44.0%, $P_{(1)}$= 0.95). The degree of exposure, age, alcohol, and marijuana use, past illness or fever, use of baths or sauna, and history of urological problems did not alter these results.

Based on the results of this study, NIOSH investigators conclude that there was no significant effect on sperm concentration or abnormal morphology according to whether men work in the wastewater treatment plant of the oil refinery, elsewhere in the refinery, or in administrative positions. Recommendations for environmental and medical surveillance follow-up are incorporated in Section VII of this report.

KEYWORDS: SIC 2911 (Petroleum Refining); wastewater treatment; sperm concentration; sperm morphology; reproductive health.

## II. INTRODUCTION

On September 20, 1982, an authorized representative of employees submitted a Health Hazard Evaluation request regarding a possible reproductive health hazard to male workers employed in the wastewater treatment plant of the Exxon oil refinery at Baton Rouge, Louisiana.

In 1981, an apparent excess rate of spontaneous abortions among the wives of workers in the wastewater treatment plant of a large refinery was investigated by an epidemiology consulting group at the request of the Exxon Corporation. A questionnaire survey was conducted among the workers' partners (11). The study found that for nonexposed wives, the rate of spontaneous abortions was higher when the husband worked in the treatment plant near conception than when he did not (17.0% and 8.2%, respectively). Interpretation of this study was limited, however, by methodologic problems and an inability to distinguish a male-mediated effect from a maternal effect. Because of the continuing concern about reproductive risk from working in the plant, NIOSH investigators conducted a cross-sectional evaluation of sperm concentration and the proportion of sperm with abnormal morphology in exposed workers and two groups of unexposed men. A letter explaining the purpose of the study was distributed to all wastewater treatment workers and a randomly selected control group of other refinery and administrative workers prior to the site visit to interview possible participants and collect semen samples. The field study was conducted between December 15 and 22, 1982.

## III. BACKGROUND

Description of the refinery and work force: This facility refines crude petroleum into a variety of products, including motor fuels, lubricants, and specialty products such as asphalt. The plant processes approximately 500,000 barrels of crude oil daily and employs about 2,050 workers. Water used in the refinery for cooling, washing, and extraction is contaminated mainly by organic compounds and is purified in the wastewater treatment plant. This plant, which has been in operation since 1976, consists of a large flotation tank for removing oil residues, settling tanks for separating solids, and aeration tanks for degrading biological materials.

Refinery workers are divided into two groups, mechanical and process. Workers classified as mechanical include craftsmen such as pipefitters, electricians, machinists, and other technicians who work full-time in the refinery yard. Process workers spend some of their time in control rooms and other buildings as well as in the refinery proper. The refinery operates three shifts a day, and employees work an 8-hour shift, 5 days a week.

## IV. EVALUATION DESIGN AND METHODS

### A. Selection of Participants

Exposed subjects: Of the 68 men (36 process and 32 mechanical) employed in the wastewater treatment plant during the 6 months before this study, six were ineligible because of vasectomy or unavailable because of vacation at the time of the study. Semen samples were provided by 42 (68%) of the 62 men eligible for study, divided evenly between process and mechanical workers. The number of hours worked in the wastewater treatment plant during each of the previous 6 months was abstracted from employment records and confirmed by each man. With the concurrence of union and company representatives, each man's time on the job was weighted according to his job classification. Among the process workers, supervisors had their time weighted by a factor of 0.4, indicating that these men spent 40% of their time in the wastewater treatment plant itself. Assistant supervisors' times were weighted by 0.6. Mechanical and other process workers, who spend all their time in the wastewater treatment plant, had a weighting factor of 1.0.

Unexposed subjects: Two comparison groups of 100 men each were randomly selected from company records. The first consisted of an equal number of process and mechanical workers from areas of the refinery other than the wastewater treatment plant. Of the 50 process workers, 10 were excluded because of vasectomy, vacation, or job duties which occasionally brought them into the treatment plant area. Semen samples were provided by 17 (43%) of the 40 eligible process workers. Among the 50 mechanical workers, 5 were ineligible because of occasional work in the treatment plant contact, and 3 were on vacation. Of the 42 eligible mechanical workers, 21 (50%) participated. The participation rate among unexposed refinery workers was 46%.

A second comparison group included 100 men in administrative positions, whose duties did not bring them to areas where refining occurred. Of these 100 men, 15 were ineligible because of vacation or because they had worked in the refinery during the previous 6 months. Of 85 eligible men, 36 (42%) participated. The overall participation among the 167 eligible unexposed subjects was 44%.

### B. Questionnaire, physical examination, and specimen collection

Each eligible man who agreed to participate filled out a questionnaire and underwent a physical examination concentrating on the urogenital tract (See Table 1). Each participant was given a plastic urine container and written instructions on the method of sample collection. Semen specimens were collected at home by masturbation into the containers after at least 2 days of sexual abstinence and brought to an on-site laboratory within 3 hours of collection at the beginning of the work shift.

C. Processing of samples

Each sample was processed by assigning it a nonsequential code number, gently mixing it with a pipette, measuring the semen volume, and making thin air-dried smears for later analysis of morphology. The remainder of the sample was transferred to a small vial, frozen on dry ice, and shipped, along with the smears, to the Reproductive Biology Section, Lawrence Livermore National Laboratory, for determination of semen volume, sperm concentration, and sperm morphology. The number of samples used for determining concentration and morphology differed slightly because some samples were not adequate for both determinations.

D. Analysis of concentration and morphology

To measure concentration, the frozen specimens were thawed and volume was determined by graduated pipette. Samples were gently and thoroughly mixed, then diluted 1:10 using phosphate-buffered saline with 3% formalin. Eight readings were made with a hemocytometer for each sperm sample and average concentration calculated. To analyze morphology, the air-dried smears which had been prepared from fresh semen specimens were stained with Papanicolaou's stain. For each sample, 500 sperm were evaluated according to the nine categories of shape described by Wyrobek et al. (12) to determine the total proportion of abnormal sperm.

E. Statistical Analysis

After adjustment of the sperm concentration data to approximate a normal distribution, data for exposed and nonexposed groups were compared using a one-sided t-test, with equality of variance evaluated by the folded-f statistic (14). For comparisons within groups, analysis of covariance was used (14). The presence of factors associated with concentration or morphology and of exposure that might have distorted comparisons using the t-test was tested with analysis of covariance and a stepwise regression model (14). This multivariable technique determines the ability of exposure and other variables to predict the outcome measure (concentration or morphology).

## V. RESULTS

### Characteristics of the groups

The exposed and unexposed groups are generally similar for characteristics determined by questionnaire and physical examination (Table 1). The groups differed among mean period of sexual abstinence, proportion with other occupational exposures during the past year, and proportion of nonsmokers. The possibility that these or other characteristics in Table 1 distorted the comparison of sperm between exposed and unexposed groups were tested using a multivariate model (see below). Among the unexposed group, the average sperm concentration and proportion of abnormal sperm forms were similar to those from other occupational studies using similar methods of analysis (12,15).

Sperm concentration

Among the unexposed subjects, refinery workers classified as mechanical did not differ from process or administrative workers with respect to sperm concentration ($P_{(2)} = 0.99$). Thus, all unexposed subjects were pooled to form a single group of 71 persons. Comparison of square-root transformed sperm concentrations (see Evaluation Design and Methods) showed a higher mean value for the unexposed group than that for the exposed men (99.2 ± 85.4 and 74.0 ± 63.1 million/$cm^3$, mean ± standard deviation, respectively; $P_{(1)} = 0.06$). Stepwise linear regression analysis was performed to determine whether any of the factors listed in Table 1 affected this comparison; sexual abstinence period was the only significant factor ($P_{(1)} = 0.01$). After adjustment for abstinence by analysis of covariance, the mean concentrations of the exposed and unexposed cohorts did not differ significantly (66.9 ± 10.5 and 80.8 ± 8.6 million/$cm^3$, mean ± standard error of square-root transformed mean $P_{(1)} = 0.16$, Table 2).

Among the 42 exposed men, the number of hours worked in the plant over the previous 3 or 6 months was poorly associated with concentration after adjusting for abstinence period using a multiple regression model ($P_{(1)} = 0.16$). No other factors were found to be significantly related to sperm concentration or morphology in this group.

Sperm morphology

Among the unexposed subjects, morphology did not differ according to job classification ($P_{(2)} = 0.70$), and unexposed subjects were combined to form a single group of 73 persons (Table 2). After adjustment for abstinence, the mean proportion of abnormally shaped sperm in the exposed and unexposed groups did not differ significantly (44.0% and 48.8%, respectively, $p_{(1)}=0.95$.

Among the 39 exposed persons for whom sperm morphology data were available, there was no significant linear relationship between the proportion of abnormally shaped sperm formed and hours worked in the wastewater plant ($P_{(1)} = 0.08$). The factor most highly correlated with morphology was fever ($P_{(1)} = 0.13$). Neither abstinence period ($P_{(1)} = 0.29$), nor other factors in Table 1 ($P_{(1)}$ more than 0.10) were significantly correlated.

## VI. DISCUSSION

Recent human studies have demonstrated that male exposures may have an effect on the likelihood of spontaneous abortion (1,2). Work in a variety of animals has shown that male exposures can affect reproduction even when there is no female exposure (16). For example, decreased sperm concentration and increased proportion of abnormally shaped sperm are associated with infertility (3,4) and in a less certain way with increased rates of spontaneous abortion (5-8, 17).

These data indicate no significant differences in sperm concentration or proportion of abnormal morphology among men working in the wastewater treatment plant in comparison with those working elsewhere in the refinery or in administrative positions, when adjusted for abstinence time. These results did not change when the effects of age, cigarette smoking, alcohol, marijuana use, or other factors were considered. In addition, there was no evidence to suggest a relationship between number of hours worked in the wastewater treatment plant and either a decrease in sperm concentration or an increase in the proportion of abnormally shaped sperm.

The number of subjects studied may limit the ability to detect a small change in sperm even if an underlying difference is present. Our sample of 39 exposed and 73 unexposed men was sufficient to have had an 80% chance to detect a 15% or greater departure in abnormally shaped sperm from the unexposed mean (adjusted for abstinence period) of 48.8% (18). For concentration, our sample size allowed an 80% chance to detect a decrease of at least 39% compared with the adjusted mean for the unexposed group of 80.8 million/$cm^3$.

The previous (1981) study of spontaneous abortions and stillbirths among wives of (then) currently employed wastewater treatment plant workers found a rate of spontaneous abortions among pregnancies occurring between 1936 and 1981, when men did not work in the plant, of 8.2% (11). This rate is approximately half that expected in the general population (19). The rate between 1976 and 1981, when men worked in the plant, was 17.0%. This discrepancy may be due to difficulty in remembering spontaneous abortions in the distant past as opposed to the recent past; secondly, the small number of spontaneous abortions which the study considered raises the possibility of random fluctuations in their occurrence. The second explanation is that a factor or substance toxic to the developing embryo, perhaps transmitted through skin, clothes contact, or semen, may have led to spontaneous abortions even after fertilization by normal sperm.

Thus, while our findings suggest a lack of an effect on sperm concentration and morphology of currently working in this plant in comparison with other workers in the refinery, they do not indicate whether a problem may have been present in the past. Finally, it remains possible that the semen of both populations in the refinery may

be affected. This study did not address this question; however, the average sperm concentration and proportion of abnormal forms are similar to those from other occupational studies and clinical data.

## VII. RECOMMENDATIONS

1. The engineering control and work practice improvements initiated in the wastewater treatment plant should be continued and monitored by regular industrial hygiene measurements of airborne organic compounds. Efforts should be made to quantitatively characterize and compare the exposures in different sections of the plant and to identify if such exposures have been found in other animal or human studies to be suspected male reproductive hazards.

2. Although the results of this study showed no significant effect on sperm concentration or abnormal morphology, a previous questionnaire study involving this group of workers showed an apparent excess of spontaneous abortions among the workers' wives. Thus, continued monitoring of pregnancy outcomes among the refinery workers would be advisable in order to assure that there is no continuing problem. If follow-up monitoring confirms an increased incidence of spontaneous abortions, further medical testing of exposed workers, which might include a reevaluation of sperm quality parameters, should be conducted.

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## IX. AUTHORSHIP AND ACKNOWLEDGEMENTS:

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1. International Brotherhood of Electrical Workers, L.U. 767, Baton Rouge, LA.
2. Baton Rouge Oil and Chemical Workers Union, Baton Rouge, LA.
3. Exxon Corporation, Baton Rouge, LA.
4. NIOSH, Region VI
5. OSHA, Region VI

For the purpose of informing affected employees, copies of this report shall be posted by the employer in a prominent place accessible to the employees for a period of 30 calendar days.

Table 1

Characteristics of Exposed and Unexposed
Refinery Workers

| Characteristic | Exposed N = 42[8] | Unexposed N = 73[8] |
|---|---|---|
| Age (years)[1] | 31.6 ± 5.3 | 34.9 ± 10.4 |
| Sexual abstinence (days)[1] | 2.9 ± 1.3 | 3.6 ± 2.9 |
| Abnormal physical examination[2](%) | 9.5 | 16.2 |
| Other occupational exposures[3](%) | 25.7 | 47.6 |
| Abnormal medical history[4](%) | 25.7 | 16.7 |
| Fever[5](%) | 8.1 | 9.5 |
| Use of prescription drugs[6](%) | 12.1 | 14.3 |
| Use of sauna or hot tubs[7](%) | 21.6 | 33.3 |
| Use of cigarettes (packs/day)(%) | | |
| None | 78.4 | 61.9 |
| less than 1 | 6.8 | 7.1 |
| 1 | 9.5 | 21.4 |
| 2 | 5.4 | 7.1 |
| 3+ | 0.0 | 2.4 |
| Marijuana use (%) | 9.5 | 19.1 |
| Use of alcohol (drinks/day) (%) | | |
| None | 18.9 | 21.4 |
| less than 1 | 14.9 | 21.4 |
| 1-3 | 44.6 | 23.8 |
| 3+ | 21.6 | 33.3 |

[1]Mean ± standard deviation
[2] Presence of varicocele, hydrocele, hernia, or single testicle
[3]To solvents, formaldehyde, coal, dyes, or lead within past year
[4]History of hepatitis, urinary tract infection, mononucleosis, varicocele, or diabetes mellitus
[5]At least 101°F in past 3 months
[6]Antibiotics, propranolol, or cimetidine in past 3 months
[7]Weekly or more frequent use
[8]Excludes missing responses, except where noted

Table 2

Sperm Concentration and Proportion of Sperm with Abnormal Morphology among Refinery Workers

| Exposure group | Sperm ----Concentration[1]---- No. Subjects[3] | Mean | Standard Deviation | Sperm -------Morphology[2]------ No Subjects[3] | Mean | Standard Deviation |
|---|---|---|---|---|---|---|
| Exposed | | | | | | |
| Process | 21 | 65.4 | 60.6 | 19 | 40.9 | 9.0 |
| Mechanical | 21 | 82.6 | 65.8 | 20 | 47.9 | 15.9 |
| All subjects | 42 | 74.0 | 63.1 | 39 | 44.5 | 13.3 |
| Adjusted mean, all subjects[4] | | 66.9 | | | 44.0 | |
| Unexposed | | | | | | |
| Refinery | | | | | | |
| Process | 16 | 97.7 | 78.4 | 16 | 51.6 | 11.6 |
| Mechanical | 21 | 103.5 | 88.8 | 21 | 47.3 | 17.8 |
| Administrative | 34 | 97.3 | 88.6 | 36 | 49.2 | 15.4 |
| All subjects | 71 | 99.2 | 85.4 | 73 | 49.1 | 15.6 |
| Adjusted mean, all subjects[4] | | 80.8 | | | 48.8 | |
| Significance (adjusted means, exposed vs. unexposed subjects) | | 0.16 | | | 0.95 | |

[1]Number of sperm per milliliter of ejaculate, in millions; square root transformation used for statistical comparison.

[2]Proportion of abnormally shaped sperm based on scoring 500 sperm per sample by the criteria of Wyrobek et al. (12).

[3]Number of samples may differ for concentration and morphology because some samples were not adequate for both determinations (low volume or very low counts).

[4]Adjusted for abstinence period